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OF THE

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FERTILIZER INDUSTRY ROUND TABLE

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Theme: Materials Handling

Wednesday Morning Session, Nov. 8, 1961

The Opening Session of the Fertilizer Industry Round Table convened at nine-fifty o'clock, a.m., in the Colonial Room of the Mayflower Hotel, Washington, D. C., Vincent Sauchelli, chairman, presiding.

CHAIRMAN SAUCHELLI: Ladies and gentlemen, friends, when I say it is a great pleasure, indeed a thrill, to be back to welcome you in person, it may sound trite. You must believe me, the sentiment is really genuine.

Last year at this time I was in far off India. Your cable to me was most gracious and deeply appreciated. It was just grand of you all to do it.

Here I am and I repeat we welcome you to this 11th Round Table. Your Executive Committee has with your full cooperation prepared an excellent program. My colleagues on the Committee did most of the work once we decided upon the theme. The corps of leaders and speakers who responded to our call to cooperate in the program is ready and eager to proceed.

At this time perhaps it may be appropriate for me to make a few comments on world fertilizers. During the past twelve months I've had many opportunities to observe at first hand some important developments in fertilizer production and use which are occurring in Asia and Europe.

It is not quite 100 years since phosphate rock was discovered in South Carolina and Florida. Our commercial fertilizer industry, I believe, started with the mining and processing of river phosphate rock in South Carolina and shortly thereafter in Florida.

In 1868, about 16,000 tons of phosphate rock were used to produce about 31,000 tons of single superphosphate or 6,000 tons of P_2O_5 equivalent.

In this past year, 1960, more than 40 million tons of phosphate rock were mined in the world of which 17 and a half millions tons or 44 per cent were produced in our own country, mostly in Florida. Florida has about 70 per cent of the total.

More than six million tons of P_2O_5 in 1960 were produced by the world industry. Within a century from 6,000 to six million tons of P_2O_5.

Europe and North America now produce and consume the largest tonnages of chemical fertilizers. Other parts of the world, particularly the less advanced countries are awakening to the importance of fertilizers in the production of food, fodder and fiber. They are realizing that if their standard of living is to be raised the use of chemical fertilizers is indispensable in order to grow the food required by their ever-increasing populations.

Commercial fertilizers are man's only means by which he can maintain or increase the productivity of the soil. Commercial farming as we know it today is unthinkable without adequate supplies of nitrogen, phosphate, potash and the other plant nutrients.

Cropping involves losses of the soil's fertility, that is through the sale of farm products, leaching, and erosion of top soil; on farms where most of the crops are fed to livestock about 30 per cent of contained plant nutrients in the crops is lost. On farms without livestock only about 30 per cent of the contained plant nutrient is returned to the soil, the remainder, 70 per cent is lost.

Unless such losses are compensated for by the application of plant nutrients, most economically by chemical fertilizers, the soil's fertility and hence its productivity becomes exhausted.

In this connection may I quote from the writings of Dr. Hugh Nikol, an eminent Scot scientist, who is very knowledgeable in these matters. "Fertilizers," he says, "should be given absolute priority in thought and action by all those who are concerned with the future of man. Fertilizers have become more important for his survival than any contribution made by atomic energy or any other source of external and merely physical power. Since no nation will consent to starve cheerfully the maintenance or increase of fertilizer consumption is to a large extent decisive for guaranteeing world peace."

Nothing is more important today than fertilizers and any of the measures adapted for securing to generations to come the raw materials from which to produce fertilizers.

More than any other industry the fertilizer industry is entitled to say that it serves the most worthy scientific purposes.

Now, about nitrogen. During the decade in which our Round Table has functioned, the fertilizer industry has undergone an almost revolutionary change in its technology, marketing and corporate structure.

The nitrogen branch has made many noteworthy advances. Vast sums of money have been invested in its installations and the value of its output is enormous. This branch represents, perhaps, the most important segment of the chemical fertilizer industry.

Developments in its technology and chemistry deserve the attention of scientists everywhere.

Dr. G. Pfoser who is well known among scientists in the nitrogen field classifies as basic three different processes which have been used to tap the nitrogen resources of the atmosphere, the electric arc process, cyanamide, and the synthesis of ammonia. Of these, the synthesis of ammonia by the Haber-Bosch processes is considered the most important and the one most used throughout the world. A chemical combination of synthetic ammonia and acid radicals to form the array of nitrogen compounds which we use as fertilizer materials attests the versatility and power of modern chemical engineering.

Now, phosphates; in the field

of phosphatic fertilizers single superphosphate continues to hold its primacy owing to the simplicity and economy of its manufacture. Despite its advantages it is steadily being displaced by the concentrated phosphates, that is, triple and the ammonium phosphates.

Modern transportation costs are one of the decisive factors in the user's choice of material, especially in the export trade. Thermoelectric processes for manufacturing phosphoric acid and the increase in the production of wet process phosphoric acid are other notable developments in the phosphate industry.

As to potash, advances in the technology in the potash industry have also been commensurate with the developments in the other branches of the fertilizer industry. Vast new deposits have been discovered in Canada, Utah and some new deposits in Italy, and are being prepared for mining.

Mixed fertilizers of the NPK or NP type are being produced in many European countries and in Japan where formerly it was customary for farmers to apply material separately. Convenience and the high cost of farm labor are two factors which induce farmers to use fertilizer in the form of mixed goods.

The modern farmer is being served with a wonderful variety of chemical materials and fertilizer compounds undreamed of by his forebearers and at comparatively low cost. Can anyone question the statement that today's chemical fertilizers constitute one of the most potent factors in our country's achievement of abundance and prosperity.

We are in an era of keen industrial competition full of increasing technical complexities. To survive a firm must provide improved services to the farmer from college trained agricultural field men able to discuss a farmer's soil and crops problems intelligently. We're seeing that in all parts of the advanced countries of the world. In this country particularly there's a very strong trend in that line.

The industry needs and demands production personnel who are capable to run large, complex plants producing eleven to twelve months of the year with a sharp eye on economy.

Research and development departments are required to make greater efforts to generate improved processes. Present trends in the industry will continue; among these are more requirements in skill and in capital for investment, greater size of closely integrated continuous processes, steadily increasing complexity with phosphoric acid, different forms of nitrogen materials, more materials handling problems, need for more highly skilled operators and higher wages. Today a manufacturer of chemical fertilizer has to have a staff of skilled technical operators. Nothing less than the best chemists, engineers and chemical engineers are good enough for the fertilizer industry today.

Some of the modern techniques require large scale operation to be economical. Mergers, therefore, may be expected if greater precision in quality and quantity output is to be had.

Before proceeding with our agenda may I make a few comments on our last meeting's program. At the last sessions considerable attention was devoted to the subject of standardization of materials; suppliers and users presented their viewpoints very ably. Brief reports will be given later in the program on what has been accomplished.

It has been the policy of the Round Table to provide operation personnel, a forum, where problems of common interest to operators, could be discussed frankly and freely. We have never tried to assume standards and specifications; that is not our function and to attempt to do so might seriously hurt our organization.

Your Executive Committee was quite embarrassed by certain publicity that had been proposed for the actions of the committee on raw materials standardization. We had to take a strong stand against such publicity at that time. We sincerely trust our action was properly understood by those who were involved.

Brief interim reports will be given later in the program on what has been accomplished as the result of the discussions last November.

I have a few notices at this time; I think this would be an appropriate place to give them out. I'm appointing Bill Tucker and Roger Smith as the Auditing Committe; they will audit the Secretary-Treasurer's books, if you please.

Our Secretary tells me that the membership roster will be available as soon as possible and that those who are interested in obtaining a copy will have to, this year, pay a dollar and a half. Expenses are going up, it seems.

He also asked me to announce that we have a certain number of back numbers of proceedings for 1960, 1959 and 1958. If anyone is desirous of obtaining copies of these three proceedings our "Scotch Treasurer" is making a special price of $7.50 for the three, or if they want to obtain them singly they will be charged at the regular price.

Let us now proceed with our agenda.

The theme of this meeting is "Materials Handling." We could as well have said "Mechanical Handling" for in essence that is what is intended.

When the common laborer in a fertilizer plant was getting 35 cents or so an hour – that sounds so strange–35 cents an hour–that we oldtimers could remember that, the use of abundant manual labor was perhaps justified.

In recent years management has been forced to emphasize higher productivity per manhour and to economize on human labor as a means of reducing costs of production. The result has been that mechanical methods are rapidly replacing what in the past was done by manual labor or with the help of simplified equipment.

Materials handling in our industry is on a big-scale; vast amounts of material have to be handled in the form of raw and finished goods.

Last year the total fertilizer tonnage in the United States alone was 23 and a half million of which about 70 per cent represented mixed goods or say about 17 million tons.

To produce these tons of mixed goods involves at least one solids mixing operation; at least one basing operation is needed before final blending for shipment; hence, the actual tonnage put through mixing equipment could be near 30 million tons.

This means a materials handling job involving various operations such as unloading, loading, moving goods in and out of storage and bins and base piles. All told, the weight of materials moved in the operations of making and shipping the mixed fertilizers alone could approximate 100 million tons a year.

This excludes the huge tonnages handled in our industry at the phosphate and potash mines. Thus the materials handling job is a mammoth one in our industry.

Since our central theme, as I said, is "Materials Handling" we are fortunate to have as our leadoff speaker Mr. W. B. McClelland, Headquarters Secretary, American Material Handling Society in Cleveland, Ohio.

Mr. McClelland represents an organization of over 5,000 members of that Material Handling Society. For many years prior to his present position he worked in market surveying and in sales training. At one time in his career he taught accounting to college classes.

So, we are really privileged to have him as the keynote speaker at this session.

Mr. McClelland.

MR. W. B. MCCLELLAND (American Material Handling Society): Thank you, Dr. Sauchelli. Ladies and gentlemen. It is also a privilege to come — we people feel that material handling applies in any industry and when I was asked to come here — I don't know anything about making fertilizer but I felt that the principles in any manufacturing are the same and the principles apply here equally well as they do in any other industry, so over a telephone conversation it was decided that this would apply.

Organizing and Accounting for Material Handling in Manufacturing

W. B. McClelland

Introduction

THE words "material handling" are getting to be commonplace but still there seems to be little agreement concerning the scope of activities which the words connote.

The objectives of the American Material Handling Society, as stated in its constitution, are to advance the theory and practice of material handling. There is, however, no explanation of the meaning of the words.

It would seem that industry is ready to give new recognition to old definitions and phrases such as (a) material handling is the creation of time and place utility, (b) material handling involves all activities in industry and commerce having to do with getting the right quantity to the right place at the right time in the right condition, (c) material handling involves all activities having to do with the movement and storage of goods, (d) the material handling equation: what plus how much plus where plus when equals how. Possibly the word "Rhochremation" will become as common some day as automation is today. The words material management are being used. Is material management a part of material handling or do both terms have the same meaning? This is all confusing, but for this discussion material handling will be considered all activities in industry and commerce involved in the movement and storage of goods.

The Standard Industrial Classification Manual can be used to indicate not only the scope but the categories of material handling. Materials to be handled fall into two broad classifications: (1) those which are finished ready for use by the ultimate consumer and (2) unfinished goods or those requiring more production work before being ready for the consumer's use.

The industrial classification subdivides these two categories further:

Unfinished Goods

Division A — Agriculture, forestry, fisheries
" B — Mining
" C — Construction
" D — Manufacturing

Finished Goods

Division F — Whole and retail trade

The marketing man subdivides these into industrial goods and consumer goods.

Division E — Transportation, communication, gas electric and sanitary services.

These services are involved with both finished and unfinished goods.

This discussion will pertain to organizing and accounting for Division D activities, namely, manufacturing.

Manufacturing

The primary objective of manufacturing is the physical or chemical alteration of products found in nature to make them useable.

If we wanted to produce pure salt water, the first step would be to locate sources for water, fuel and salt. The first production operation would be to burn the fuel to distill the water and the second one to add the salt. All other activities involved are material handling and really are here to serve the production or forming operations. Could we then say that material handling management involves those activities in industry and commerce which serve production operations?

Within any manufacturing establishment the same situation exists. Certain areas are devoted to giving the product salesable shape while other areas and activities are functioning to serve these production areas. Except for those operations actually giving the product saleable shape, the activities of a manufacturing concern have to do with the moving and storage of goods.

In a manufacturing concern there are three steps or phases of these handling activities which might be termed the transit, process and distribution phases . . . getting the materials into production operations, through production operations and then away from them.

The activities involved in each of these three phases are:

Transit phase: purchasing, production planning, inventory control, transportation inbound, inspection, receiving, incoming stores and issue.

Process phase: in process stores and intra - plant transportation.

Distribution phase: outgoing stores, shipping and transportation outbound.

Then, the question for discussion, is it desireable for the manufacturer to separate the functions which give a product saleable shape from those having to do with the moving and storage of goods?

Accounting

Such an organizational setup will be difficult to sell to top management because of the problem of demonstrating benefits. Benefits are usually measured in dollars which must be accounted for accurately under present accounting procedures, but material flow costs are seldom separated into functional accounts. Instead material flow costs are usually allocated to general overhead expense accounts.

May I suggest that it might be an enlightening project to take a year's operating statement for a manufacturer and segregate (1) the overall cost for moving and storing and (2) those costs incurred for only those specific operations which make the product more saleable? In most concerns such items of cost are available but not combined as suggested. In other words, the accountant likely has the information to prepare reports as management wishes. Can we then discuss what accounting reports management might want?

Manufacturing makes profit by creating values. Could we then hinge our discussion on the cost of creating values? We were all introduced to economics by having the four values (form utility, time utility, place utility and ownership utility) explained to us. Creation of form utility is production and the creation of time and place utility is material handling. Could we then suggest that the board of directors of any manufacturing concern might have a useful basis for making decisions if the operating statement summarized:

(a) the cost of those activities directly involved in giving the product saleable shape,

(b) the cost for moving and storing of goods.

We are accustomed to the terms direct labor, direct material and burden. The direct labor and direct material are made up of those costs for activities inherent to forming the product The burden, however, includes not only supervision of product forming activities, but the cost for moving and storing goods as well.

This system served was adequate when the pyramids were built inasmuch as a large part of their cost was labor and material. With the advent of mechanization, however, the accounting pyramid seems to have been turned upside down and direct production costs become a narrow base upon which to allocate burden.

Could we then not consider cost for creating time and place value as direct for that aspect of the enterprise and thus separate those items from burden?

As with almost any other activity, moving and storing goods involves planning, controlling and executing.

As mentioned previously, material flow through a manufacturing plant involves three phases: transit, process and distribution. Could costs be summarized as to planning, controlling and executing for each phase in order to provide the board of directors with a statement something like Exhibit 9?

Does management wish to know the cost of material flow? If so, the accountant can itemize and summarize costs in order to provide such totals, if so requested. As many times as writers estimate material handling costs, there must be a desire to know. But, I'll leave this discussion of accounting with the questions:

How many manufacturers know the cost of material flow?

Is the cost of forming not distorted by having flow costs mixed with production costs?

Organizing

Organizing and accounting go together like love and marriage. We can't have one without the other. Accounting, however, was mentioned first because dollars have a great bearing on management decisions. If management would see flow costs as individual items and realize their magnitude, there might be some "courting" with the idea of organizing for material flow. We are reading and hearing about materials management, integrated material systems, science of material flow and such things. The idea is in the wind, but, apparently, no agreement as to plan is at hand.

Could we again use the four values found in industry and commerce as a springboard for discussion?

If it was logical to suggest that costs for movement and storage of goods should be separated from forming costs, is it not equally logical to suggest that manufacturing functions should be subdivided on the same basis? Isn't all this talking and writing trying to convey the idea that the director of manufacturing has but two functional categories to supervise:

1. Activities pertaining directly to giving the product saleable shape which is creating form value.
2. Movement and storage of goods which is creating time and place value.

Both of these categories are closely related so this director might need a common planning function serving both of them. The same is true concerning controlling them as a common control function might be desirable. However, the execution requirements of the two take on different aspects and require different personnel qualifications for satisfactory performance. Is the trend, then, not toward creating a position which might be titled "Material Handling Manager" where the responsibilities would include all activities having to do with getting the right material in the right quantity to the right place at the right time in the right condition. And, isn't the scope of such duties of sufficient importance to warrant that function being on the same echelon as the production manager whose responsibilities would then involve putting the product in saleable form?

When Dr. Sauchelli invited

me here, he gave me the names of some fertilizer plants in Cleveland where I might visit. My impression, after a visit to only one fertilizer plant, is that most of the activity is handling with very little space and effort devoted to giving the product physical or chemical shape. In other words, is it a fair statement to say that Material Handling Management offers more possibilities for profit improvement in the plant food industry than production management?

There are different objectives in the transit, process and distribution phases of manufacturing. Could we then discuss a plan of approach for the distribution phase of fertilizer manufacturing as an example? The distribution phase for any manufacturer is the transit phase for his customer. In this case the customer is the farmer which leads us to the point that the title of this presentation probably should have been "Material Handling on the Farm."

Objectives

Minimizing costs is the concern of everyone. One way to cut costs is to eliminate or minimize container costs. Each carton, barrel, keg, pallet or even label which accompanies the consumeable merchandise is a necessary evil. The ambition is to "get the milk from teat to tea without a can."

Planning

In planning any activity involving moving and storage there are three aspects to consider:

1. How will the material be unitized? In other words, what shall it be put in?
2. How will it be transported?
3. How will it be issued?

Basic Storage Unit

The first and most important decision in any unitization program is the determination of the units to be handled. Once established all units to be that base dimension or modules thereof. The dimensions which seem to be the most popular and deserve serious consideration are 44″ x 54″ and 40″ x 48″.

Segregation of Items by Dimensions

The first breakdown of items to be in accordance with dimensions: (a) those which can be placed on the basic storage unit and (b) those which cannot.

Characteristics of Materials

With each such item four aspects need to be considered: (1) whether the items are light or heavy—that is whether one person can lift it, (2) whether the items are uniform or non-uniform – in either condition stackable or non-stackable, (3) whether fragile, defaceable or durable and (4) whether they contaminate or are contaminated by ambient conditions.

Design Objectives

Now, let's talk about design objectives. In planning a unitization program, the following goals should be kept in mind:

1. Units can be readily filled at supplying point.
2. Units can be transported on flat bed carriers.
3. Can be stored out-of-doors.
4. Will comply with preferential freight rates, if available.
5. Can be handled with equipment used for other purposes.
6. Will dispense its contents, preferably in batch quantities, directly into operations.

Unitizing Plan

A challenge is then suggested as to whether the indicated nine categories of mechanical sized units will handle any commodity found in commerce.

1. Those which are self unitizing.
2. Those requiring nothing but a base such as a pallet.
3. Those requiring the base and four corner posts.
4. Those requiring the base, four corner posts and liners suitable for durable items.
5. The base, corner posts and leaves.
6. The base, corner posts and shelves.
7. The base, corner posts and liners suitable for granular materials.
8. The base, corner posts and liners suitable for liquids.
9. The base, corner posts and liners suitable for frozen or heated items.

How to Transport

The second aspect to consider is the method of transportation from supplier to customer. When common carriers are used one loses control in the middle of this cycle from "teat to tea." Furthermore, the modern concept of handling systems wants to consider the body of a truck an integral part of production facilities with a power plant to pull it. In addition, the packaging requirements for common carriers are far more exhaustive than is necessary for captive equipment.

Serious consideration should be given to transportation equipment which is completely controlled by the receiver of the merchandise.

Carrier to Operations

Getting goods from carrier to operations in manufacturing could involve automatic warehousing if common basic storage units are used. On the farm it can be the means of complete mechanical handling.

The above is a suggested plan of approach toward systems planning for any activity involving movement and storage of goods. Let's spend a little time trying to apply this thought pattern to activities on the farm.

As a start, consider the basic elements in farm transporting equipment fifty years ago. They consisted of a wagon with four wheels and a reach, which was the carrying element. A team of mules was the power plant and the harness was for transmitting the power to the wheels. Those elements made up the basic unit for transporting any commodity the farmer wished to move. Based upon the characteristics of the commodity to be handled, he had "containers" to handle different items With a hay rack, a stock rack, a grain bed and a stone bed, he could unitize any commodity found on the farm. And these "containers" were not permanently attached to the carrying element.

Then, the automotive industry replaced the wagon with a rubber tired frame, replaced the mules with an engine, with transmissions, propeller shafts, etc., replaced the harness, to make a motorized carrying element. For some reason, it seemed necessary to permanently fasten the bodies (containers, if you will) rigidly and permanently to the carrying element. After these many years of using motorized transporting equipment, industry has begun to realize that portable and removable truck bodies have advantages. By applying the same principles to trucks that the farmer was using before internal combustion engines were invented, we are beginning to have portable truck bodies and talking about this new containerization industry.

Then, should the equipment for an integrated handling system for the farm not consist of:

1. A motorized carrying element suitable for horizontal transportation of any agricultural commodity.
2. Removable bodies (containers) suitable for retaining these commodities.
3. Devices for transporting these commodities vertically of both permanent and portable types.

Now, let's try to apply this basic thinking to fertilizer. If a farmer had such an integrated system for handling, he might arrive at a fertilizer plant with a flat bed semi-trailer on which were containers, say 44″x27″x40″ high, into each of which he would like to have placed one ton of fertilizer. If these were weatherproofed, he could remove them from the semi with a portable elevator (farm tractor with a fork type mast) and store them in the barn yard, or in the field where he intended to plant crops. With this same portable elevator he could dispense the contents of the containers directly into the drill or whatever machine was planting the crop. The seed could be handled in the same manner. When harvesting the crop, the same containers could be used to collect the grain and deliver it to the elevator or the feed bins.

To be workable a unitization program and an integrated handling system must be initiated and controlled by the receiver of the commodity. The supplier or vendor has unsolvable problems if he undertakes to provide a system for his customers. This is an association of manufacturers. Could you not interest a similar association of your customers in the idea of devising integrated handling systems for farm commodities suitable for your products as well as others which the farmer handles?

Chairman Sauchelli: Thank you, Mr. McClelland. That certainly was a splendid analysis of a problem that is of direct, very direct interest today to the fertilizer industry.

We have time for some questions and I think there will be some questions asked of the speaker. He's prepared to enlarge on any phase of the subject that he has presented, and this of course has always been our specialty, to ask questions and have the audience participate in the discussions. I'm sure he's given us a lot of food for thought, serious thought, and questions could be in order.

Mr. Reichard: In the latter part of the speech you talk about integrated units controlled by the receiver. Is there anything you have in mind that uses that kind of equipment?

Mr. McClelland: If I understood the question correctly, it basically is this: do you know anybody that is offering for sale such a thing. The answer is certainly no.

Would you please analyze what the Material Handling Industry consists of?

It consists of, first, a bunch of people making conveyors; it consists, second, of a bunch of people making bulk trucks and so forth, your basic handling component, and the container industry is primarily made up of fabricators making something else; you show me somebody in industry who's making his living out of portable truck bodies. There is nothing to my mind that manufacturers need more than for some—may I use the word "General Contractor" to approach you and say "I will install a system for you." You can't buy a system, to my knowledge; it takes a minimum of seven suppliers to get this and they aren't connected; their designs aren't the same and when you put them together, you've got problems. That's one of the big reasons.

Chairman Sauchelli: Are there other questions or comments?

Mr. Fischer: There is a unti being made in industry that is, let's say, slightly related to the fertilizer industry which is integrated for that specific purpose. Mr. Geisenheyner is going to talk about pressurized bulk trucks, the transport. The explosives industry has developed a bulk truck for handling ammonium nitrate which is also a fertilizer and for distributing it through quarries. The purpose of the truck is to take a load of ammonium nitrate, transport it to the quarry and deliver it directly to the blast hole that has been drilled to receive it.

This eliminates the intermediate handling that takes place between the manufacturer and the consumer. The truck delivers the load that can be regulated and mixed with other materials, if necessary, all in one operation.

Chairman Sauchelli: Thank you, Mr. Fischer.

Mr. McClelland: He helped make my point for me. There are systems for sale to handle fertilizer. There are systems for sale to handle this; but, to me, that's a system for a product. Now let's get over—just grab one—the appliance industry. Sure, there are containers and portable truck bodies available to handle their granular materials, but how do they handle all the other items they have to make?

My point is that you haven't got a system until you can take the bill of material of any manufacturer and put every item he handles into the same system. Sure, we've got systems for products, but we haven't got—to my knowledge — integrated handling systems for a manufacturer.

Chairman Sauchelli: This is the sort of thing we like. This kind of discussion.

Mr. Webber: I might mention that in Scotland, the Scottish Agriculture Industries has very extensively developed a system of contract—they are producers of fertilizers—of contracting to actually apply the fertilizers to the field. They just make a contract with the farmers to apply so and so much, so much fertilizer at a certain time on their fields and the farmer forgets about it from then on.

As a result, they have gone very extensively into this question of unitized containers and transportation and application, very much along the line that Mr. McClelland is indicating.

They can afford to do it, of course, because they've developed this thing quite extensively and they can therefore standardize it. They're not having to deal with individual farmers who have individual types of equipment that their containers would have to fit into, but they supply the whole thing from plant to field themselves.

CHAIRMAN SAUCHELLI: Thank you. I'm glad you mentioned that. I'm quite familiar with that. That certainly has been a very interesting development.

CHAIRMAN SAUCHELLI: Yes, sir.

MR. J. G. SCHRODER: I'd like to call on Mr. Webber, actually. I just returned from Scotland and in our industry I was going to ask why he thought that the manufacturer would not partake in the actual application; he suggested, I think, that some other body should take responsibility for getting the fertilizer to the field without them touching the container.

Now we have been dealing very closely as far as agriculture industries and I'll qualify Mr. Webber's remarks by stating that this applies to grasslands only. The Scottish Agriculture Industries have ventured into the field of application by methods outlined, rather than grassland problems, so the matter, of course, is applied here.

Our problems are very great. We recognize them, of course. That there's too much going in, left us spending thousands of pounds, so they got started in this business of getting it out there to the field.

There is profit to be made out of distribution, but it's a darned hard side to manage. It's a challenge and I'd suggest to Mr. McClelland—I'd like to ask him the question, why he says some other organization has to come in and do this for you? (Applause.)

MR. MCCLELLAND: I don't know that I intended to infer that some other organization had to come in and do it for you. What I tried to infer was that you, as a manufacturer, can accomplish lots more in the way of savings by you starting your integrated system with the things which you purchase.

Now, as one comparatively trivial example: if you would get a returnable truck body, containers, we're trying to call them, you've got quite an investment and you give it to your customer and they don't come back. What can you do? Please, mister, send it back.

But you have owned this re turnable container and sent it to your vendor, you're not so damned polite, you just say, send them back or I'm not okaying the invoice for this shipment that didn't come back. One of the items.

Want another one? In the cycle in which all materials move, whether it be the transit phase or distribution phase, the returnable truck body will spend most of its time in the location of the receiver and it becomes his bank, his birdfeeder, as I said; therefore, why should you provide the storage capacity for his incoming storage? I could list eight or nine more.

I didn't say you couldn't. Now, would you like to do it the other way? You've got the most wonderful sales gimmick in the world, starting this thing on your distribution side, and I cite one man who's doing it extremely successfully. He owns his own fleet of trucks; he owns all the containers himself. He has consigned X number to each of his customers by memo billing; whatever they say he's providing the incoming storage and he tells his drivers, when you arrive at the dock with ten of them you bring back ten empties or you call me, and he makes it work.

I did not try to infer that you had to have somebody else doing this; I say you're in a much better position to control the system on the items you purchase than you are on the items you sell. That's all.

CHAIRMAN SAUCHELLI: Yes, sir.

A MEMBER: As more and more new plants are coming into production, all the plant managers have a lot of ideas of how to economize, but I'm amused sometimes in our own setup where the most economical method we have is to haul away the trash, but the trouble is we create too much trash every day. The whole problem is of education, I think, down on maybe the farm. In the farm industry you have individuals, cross-sections, you have one fellow who wants a 50 pound bag, an 80 pound bag, a 100 pound bag. Another fellow doesn't want to leave the brakes open, he wants you to leave them open for him. It's a certain somebody that may want a bulk shipment, but they won't have a truck; it has to load from the top, and this, that and the other; so you get into all of these things which put all the brains gather together and decide this is the way to do this. But as soon as you hit the fertilizer industry, I don't know just why it is, but over a period of years, maybe on the college level where something, if you could educate these people, they could realize that if they would standardize their average to a certain extent, they in turn would realize some of the benefits of the almighty dollar.

CHAIRMAN SAUCHELLI: Any other comments?

This is a very important subject and one that, as I said at the beginning, is very close to the industry and I'm sure a lot of thought will be given more and more to this whole idea of materials handling.

Well, we're going to continue on this subject. The program will continue with a discussion divided into two parts on bulk solids. The first part is going to be discussed by John Fischer, who is with the Sprout-Waldron Company of Muncy, Pennsylvania, an organization that, as I understand, has been in this manufacturing business almost a century and does business world-wide.

We are very glad to have you, Mr. Fischer, discuss the pneumatic systems.

Pneumatic Systems

John Fischer

Thank you very much, Dr. Sauchelli, ladies, gentlemen.

Before I start to talk about

pneumatic systems I'd like to mention that the American Society for Mechanical Engineers is having their winter annual meeting in New York starting November 27 and the Materials Handling Section of the Society is putting on two sessions on the first day.

The program for the second session, which will start at 2:30 that afternoon will consist of a paper on Bulk Solids Handling, in this instance it's unrelated to your product, but it is a dry chemical (alumina).

The paper is being presented by Mr. West of the Reynolds Aluminum Company and it describes a very interesting bulk system for loading cars from storage at the rate of seven and eight hundred tons per hour. Many of your gentlemen may be interested in attending that session.

Now, the purpose of my discussion here is not specifically descriptive or instructive; it's provocative. The field of pneumatic handling isn't new, but the bulk handling of inorganic fertilizer chemicals, all chemicals for that matter, is just out of its swaddling clothes. It's growth has been tied to economic and human factors, as Mr. McClelland mentioned, economic because of rising labor costs and human because of the greater consideration for the safety of the individual.

There are cases in point, indeed, where the significance of these two factors is so great that other benefits accrued are merely incidental.

So, what I want to do is to promote and stimulate consideration of pneumatic handling of fertilizer and fertilizer components because it has many distinct advantages as far as labor saving, cleanliness, safety and automation are concerned.

Now, don't get me wrong. It's not a panacea; it's not a cure-all for all your handling problems; there are lots of things we have to learn.

As a matter of fact, there aren't too many systems in operation at the present time. Most of them are mechanical. You all know a great deal about mechanical systems; perhaps more than I do, so I'm not going to try to make any comparison between mechanical and pneumatic.

I had intended at the outset to discuss some of the theory of pneumatic conveying. I'm going to confine my remarks on that subject to simply stating that pneumatic conveying, strictly defined, is the movement of dry, free-flowing solids through pipes by air. The energy for conveying comes from the air itself, flowing past particles.

We have negative systems in which the air is drawn in from the end of the pipe and exhausted at the terminus of the system, at which point the material is separate from the air.

We have positive systems where the air is introduced into a pipe against a high pressure and blown to its destination.

We have pull-push systems which combine both features. They suck and then transfer the rest of the way by pressure.

It might be helpful at this point to discuss the factors which determine whether you select the negative system or the positive system for your handling problem. Actually, there is no difference in the power requirements; the same amount of air is doing the same job regardless of the direction in which you deliver it. The choice boils down to a matter of cost, a consideration of plant requirements as well, and economy. Generally speaking, the first cost of a pneumatic system will favor the following method of selection.

A negative system is used when there are several inlet points. If you are picking up from a great many storage sites and you want to take it all to one place, such as a truck loading point.

A positive system is selected if you want to discharge the material into the system at only one or two points but distribute it to a great many different places.

There are often applications where you require a high degree of flexibility, where you want to be able to have your point of inlet over a fairly wide area and you want to discharge over a fairly wide area, then the cost favors a combination, the pull-push system.

Down in Kentucky there is an installation at one of the large cooperatives which sell and distribute fertilizer to its members. This is a specific problem which they had. You might call it a case history.

They bought and received 4,000 tons more or less of mixed fertilizer per year in bags, they had to handle it from box cars into their warehouse, load it into bulk storage bins so that they could discharge it from these bulk storage bins by gravity into trucks, the trucks then took it out in the field and distributed it for the customer. These were spreader trucks, they carried four to six tons a piece, and at peak seasons they had a helluva time because they couldn't handle bags fast enough and it took too long between trucks.

They investigated the possibility of receiving not mixed fertilizer but individual fertilizers, in this case specifically muriate of potash and triple super phosphate, in railroad hopper cars, which were pneumatically unloaded into the gravity feed bins for the trucks.

A system was designed for them that would unload at the rate of 25,000 pounds an hour; that would discharge a car roughly in four hours. That means that a car could be spotted on the siding in the morning and the crew, before going off duty in the evening, could come back and pick the car up and take it out, very little demurrage. There was no handling, no labor involved.

When the customer called, the truck drove under the bin, loaded up and was on its way in a very short period of time.

The customer had some concern that there would be trouble with this system because it was suspected that fertilizer chemicals with the best physical and chemical characteristics wouldn't be compatible with the pneumatic handling system. The converse has proved true. They have had less trouble with the pneumatic handling than they had with the mechanical system that they used to use.

The way in which the system was designed a pit was built beneath the rail with a hopper located over a rotary valve. The rotary valve, if you can visualize it, is nothing more or less than a revolving door so that material dropping into it on one side can be introduced into a high pressure air conveying stream on the other and taken away. This rotary valve is an air lock. It prevents the high pressure air from escaping back and keeping the material from flowing into the system, from blowing all over, in fact.

This material is moved then by a relatively small quantity of air over a distance of 157 feet. There are 5 distinct changes of direction in this course of 157 feet; 37 feet are vertical to go up to the bins.

This illustrates one of the chief advantages to be found in pneumatic conveying, pneumatic handling. Your conveying channel is a pipe and a pipe can go anywhere, you can run it underground, you can run it overhead, you can run it across the ceiling, in the corner of a building, or you can span streams and rivers with a pipe, and it doesn't cost too much to put it in. When the pipe wears out, which it sometimes does, it doesn't cost much to replace it.

The system actually functions much better than anybody suspected. They have consistently delivered from their cars to their storage silos at the rate of 40,000 pounds per hour instead of the 25,000 pounds per hour design figure. This is because possibly we were conservative in our designs. It is also due to the fact that we were not too familiar with the characteristics of fertilizer, the bulk density being one of the factors which entered into our calculations and we assumed the packed bulk density of fertilizer rather than the loose bulk density.

The power requirements on this particular system.

Thirty horsepower was all that was required to transport that 40,000 pounds an hour. That seems like a lot when you consider that a mechanical system with the same distance might not require more than 10 horsepower, a horizontal screw, or belt conveyor, then an elevator or a vertical screw system. But where could you get a mechanical system to negotiate 5 changes of direction and still use 30 horsepower? And also minimize the amount of maintenance that you accomplish with a pneumatic system?

At this installation, the material is blown into bins which are just vented to atmosphere. However, had dust been a problem it would have been easy to contain it by using dust collectors, by using stockings or wet scrubbers, depending on the nature of the material. Here it wasn't any particular problem.

This is characteristic of pneumatic handling that dust is generated at either the beginning or end of the system. In between, where it is flowing through the pipe, there need be no dust and there is practically never any dust, except if they are sloppy or careless in installation and assembly or if and when a hole is created in the pipe.

Now, one of the major problems that we have been concerned with in the handling of such material is breakage and abrasion. I am not too well acquainted with your problems of manufacturing distribution, but I would assume that a lot of fertilizer ingredients depend for their effectiveness on particle size which enables control at dispersal into the soil and also has something to do with their ability to float, an exception might be when it goes into a liquid state at handling.

We cannot prevent abrasion of such materials in pneumatic handling because the air is traveling at a fairly high velocity, and as a result the particles that are being conveyed by the air tend to attain or try to reach those velocities. For example, the velocity has to be equal to or greater than the traveling velocity of the individual particles, and a figure with which we often start our calculations is 5,000 feet per minute. Now, 5,000 feet per minute is pretty close to a mile a minute, and when you start moving small pieces of chemical through pipe at the rate of a mile a minute, when it hits something, it's going to break.

At the same time, going at this rate, where it enters an elbow, where its direction is changed, it not only has a tendency toward breaking but there is an equal reaction in the elbow itself causing abrasion or erosion, depending on the hardness of the material being handled.

We have two ways of tackling such a problem. One, is to try to slow down the system, because we find that breakage and abrasion is an exponential factor of velocity, and everybody in the technical area of the field is more or less in agreement that the faster material is moved, the more rapid wear becomes and the greater breakage occurs. What we are not agreed on is what the degree is. We all know that if we slow down a system we can reduce the breakage and abrasion considerably.

There are two ways of slowing down a system. One, of course, is to use less air to move the material, and the other is to put more material in the line so that the material serves to quicken itself, there isn't so much room for individual particles to travel a great enough distance to attain the momentum necessary to creat breakage or abrasion.

The second way is to beef up the system, make it heavy enough so that the time required for abrasion to make itself a problem is within the economic considerations of the system itself. Instead of using ten gage pipe or schedule 40 iron pipe for conveying, use schedule 80. The additional cost at installation is overriden by the additional life expectancy of such a system.

In the design of the rotary valve and the other parts of the system where the material contacts either at the inlet or at the discharge, nickel-steel alloys and other materials, sometimes even concrete and stone are used to make them long-lasting.

Still another problem, and this refers now to mixed fertilizers which was not handled. Why, I have not been able to find out, why these people went to individual components rather than to the mixed fertilizer, because I believe that the mixed fertilizers could have been handled equally well by the pneumatic system. It's possible they were worried about what you might call segregation, the fact that in the process of being conveyed to storage there would be separation in the system or in the storage bin. This is a distinct possibility; we have seen it happen.

What happens is that — we're pretty sure — it doesn't segregate or separate in the pneumatic system, it separates after it leaves the system as it falls out of the system into the bins. It's possible many of you have seen the same thing when you have tried to convey mechanically and discharge into a deep storage bin. The fine and the coarse particles will tend to stratify.

Had such a problem presented itself to us, we could possibly have availed ourselves of a number of devices which are now on the market to contain that problem. There are chutes and baffles and other structures which can be placed inside a storage bin to interrupt the flow and to diminish the effect of different particle size on segregation.

I would like now to mention also that pneumatic handling is not necessarily confined to the distribution end of the business. It can play a very significant part in the plant, because of the nature of many of the materials which you work with, and I am referring here specifically to the fact that some of them may be highly sensitive to moisture. You desire either that they pick up no moisture or conversely in some instances that they lose no moisture. Ammonium nitrate is a specific example, since it is somewhat hygroscopic.

Pneumatic systems can be designed to take care of this problem also in two ways. One, you can dehumidify the air entering the system, or you can use the air which does the conveying over and over again so that the first batch of material through the system has created an equilibrium condition in the conveying air.

This is done by returning the conveying air through a filter or through some other device that separates the material from the air, returning the air to the point of origin and letting it run around and around the system.

Just one more point with regard to pneumatic systems and the part which they play in bulk transportation. They are used not only for loading cars but also for unloading cars. Our principal concern for a good many years has been delivering from the car to storage at the consumer's siding. However, pneumatic loading of cars is becoming more and more common. Most plants have been using gravity and mechanical means for loading cars, but there is no reason why if considerations of space, layout, power, anything you care to think of, enter into the picture, pneumatic systems won't do as an effective job.

Unloading cars is a horse of a different color, because here we are up against a problem which the railroads and the car builders have created. Most material is handled in ordinary hopper cars. The construction of the ordinary hopper car is such that the gates at the bottom of the hopper are supposed to be eight inches above the top of the rail. Recent ICC regulations have taken into consideration the fact that it practically is never eight inches from the bottom of the rail; it is more often anywhere from four to six inches. You cannot get a device above the rail under the hopper that will do an effective job when you only have four to six inches to fit into.

Further, it is an awkward and difficult job for a man, especially in rainy weather or in cold weather to get to crouch down on his hands and knees and try to make that connection. So we have advocated mechanical devices for removing material from cars, but they must be placed under the rail.

This involves problems also. For example, some people can't put in pits. Pits can be made waterproof, but if you have surface water conditions, it's not always too practical a method.

I want to say that it is possible to unload these cars with suction systems using a flat pan which is attached to the bottom of the hopper car, but it is not the best way in the world to do it. It is a port in a storm, you might say.

The car manufacturers have recognized this problem and there is a great deal of activity in that particular industry today on the design of cars for bulk solid handling with particular attention being paid not to the cheapness of the car and the simplicity of its construction but to the problem of getting the stuff out of the car at the other end and into the consumer's plant.

In connection with that I want to mention that a lot of experimental work is being done now by people like American Car and Foundry who have developed what they call a center flow car which has a single hopper discharge point under the car instead of double ones. Pullman Standard is working on new types of discharge gates for adaptation to pneumatic unloading systems, and General American Transportation Company has over 500 dry flow cars in operation today in which the customer simply hooks a suction nozzle to an outlet on the car and turns on the system and walks away and the material is delivered right into his inside storage or outside storage, as the case may be.

I hope that I have given you people here today a little bit of a foundation on which to do some thinking and perhaps dreaming about the possibilities of using pneumatic systems for handling your material.

Thank you.

CHAIRMAN SAUCHELLI: Thank you, John.

We have a few minutes for some questions. This paper has given some very concrete examples and so on. I know that it stirred up some thinking on your part and he is prepared to answer or comment further on some specific points. Who has the first question?

MR. JOSEPH SMITH: About what is your maximum size particle you can run through these pneumatic systems? What's your upper limit?

MR. FISCHER: That's a hard question to answer. I'd say as a rule particle size, upper limit, would be an inch and a half.

CHAIRMAN SAUCHELLI: An inch and a half, you say, is the upper limit?

MR. FISCHER: Yes.

CHAIRMAN SAUCHELLI: The person over here.

MR. ROBERT L. SOMERVILLE: I would like to know whether you consider it practical to handle the granular production that is made in most of our fertilizer plants today? Most fertilizer, not most, but a great deal of fertilizer today is produced as granules in the minus 6-plus 10 range. It is important that we do not degrade this material because the fines must be returned to the process. The material is moderately high, it runs about 60 pounds per cubic foot, bulk density.

MR. FISCHER: On the basis of the operation of the system which I described, I can say that segregation or breakage of the particles was within tolerable limits, but I would further say that it must always be determined by tests, if possible, in advance, what the tolerable limits of breakage are and what compromises, if any, can be made in the design of the system to keep the breakage within those tolerable limits.

You can convey, and I'm wandering afield here, it's perfectly possible and we do convey extremely delicate substances, such as dried tomato flakes, corn flakes, other cereals, in which breakage is an even more critical problem. Those can be handled within tolerable limits. Now tolerable limits for one company may be a half of one per cent increase in fines, and for another they might tolerate ten per cent increase in fines.

The manufacturer of the conveying equipment and the purchaser have to get together on what they can stand.

CHAIRMAN SAUCHELLI: Cliff Weber.

MR. WILLIAM C. WEBER: I think that while we're considering pneumatic systems of handling it should be pointed out there are other alternatives that combine mechanical-pneumatic systems. In other words, you can use bucket elevators or bulk transfer equipment for vertical transportation and use pneumatic air slides for horizontal transportation.

My experience with pneumatic handling has been confined mostly to handling ground phosphate rock and my company in their plant designs used either one of those two systems, either a combined mechanical air slide system or a pneumatic system in pipelines such as Mr. Fischer used and discussed. The price penalty is the degree of the spacing of your collecting or delivery points. If your plant is fairly closely coupled, the combined mechanical-pneumatic system will prove to be the simplest and the cheapest. If you have to collect or deliver to several widely dispersed points, the pneumatic system in pipelines is better. However, it consumes quite a lot of power but it is usually justified.

I might comment on this possibility of transporting some of the granular fertilizers in pneumatic systems. I think this probably should be ruled out. I know of one plant which attempted it in transferring our material from processing to bulk storage and the degradation or attrition created an absolutely, almost impossible dust situation.

It's not a question of increasing the amount of fines but creating an extreme amount of dust, and this creates an almost impossible atmospheric condition in your storage and in your subsequent handling, bagging and shipping of the product.

CHAIRMAN SAUCHELLI: Mr. Goodale.

MR. CHARLES D. GOODALE: I wanted to ask, at 200 degrees fahrenheit, would it take that much cooling during the conveying?

CHAIRMAN SAUCHELLI: This is a granular product around 200 fahrenheit.

MR. FISCHER: Usually in a positive structure conveying system the pounds of air that are used to convey each pound of material is so small that there is not sufficient capacity for heat transfer. The capacity of heat transfer that takes place through the conveying duct itself is fairly small too. It amounts to about five or six b.t.u.'s per square foot per hour, so you have to have an extremely long run before you get any appreciable cooling.

CHAIRMAN SAUCHELLI: I think we will have to go to the second part of our discussion and then if we have time, we will ask more questions.

The second part will take up new methods of transportation and unloading of bulk solids. It will be discussed by Bob Geisenheyner of the Butler Manufacturing Company of Minneapolis, Minnesota. Mr. Geisenheyner tells me that truck transportation of dry flowables in trailer tanks equipped with pneumatic unloading system is a development which is about two years old and they developed it in the cement industry.

I am sure that what he has to tell us is going to be of interest and perhaps of quite practical adaptation to the fertilizer industry.

Bob.

Dry Bulk Trailer Equipment

Robert M. Geisenheyner

A NEW concept in transportation of dry flowable products is receiving nation-wide acceptance from shippers, carriers and receivers alike. The economic impact that is has on many industries is worthy of your consideration.

The sudden popularity stems from the efforts of alert engineers who envisioned a need in industry and developed equipment to satisfy this need.

Today as never before, to fight the cost-price squeeze, every area of marketing is coming under close scrutiny. Distribution — packaging, handling, warehousing and shipping—is still one of the major cost areas.

All of you who are interested in material handling know the great challenge you have to develop and improve material handling systems.

I discuss with you today only one phase of this broad field—truck transportation of dry flowables, which include fertilizers and their basic components, using a pneumatic system for unloading the product.

Trucks now haul over 50% of all cement moved in bulk. A high percentage moves in transport trailers equipped to discharge its load directly into the customer's receiving facilities. This method has already obsoleted many, and we believe will continue to obsolete all other methods of moving dry products by truck in a very short time.

Shipping by truck and unloading pneumatically is doing for the dry bulk transportation industry what the jet engine offers commercial aviation. Dry flowables were delivered before the advent of pneumatic unloading trailers, but not as efficiently, the same as the piston engine could propel an airplane almost as well as the jet engine. However, the economics of these two parallel situations made a change mandatory.

The shipping of bulk dry flowable products in the United States by truck has been in use for over 30 years. Original equipment employed in the early years was capable of transporting comparatively small loads in dump trucks or gravity discharge hoppers.

Customers' demand for service from the trucking industry, coupled with improved highways, permitted increased gross weights and prompted the availability and appearance of larger capacity trailers.

Popular during World War II and the post-war era was a trailer design incorporating an auger for the purpose of moving the product to the back of the trailer for discharge into the customer's receiving hopper located at approximately grade level.

Truck equipment perhaps most often seen transporting bulk fertilizer is a belt type trailer. Such trailers are usually open top and employ a hydraulically operated belt conveyor to move the product within the trailer to the rear for gravity discharge.

Another design trailer of the same vintage having a single taper pitch to the rear, used low pressure air diffused through a porous fabric belt to accomplish product discharge. The principle of dry product aeration having been established was now applied to unloading trailer tanks.

The birth of air unloading trailer tanks capable of conveying product directly into storage silos probably began in the form of pressure vessels used for the transportation of bulk cement for the oil well cementing industry. These tanks were small in capacity. However, the basic principle of air unloading and conveying fostered the application to over-the-road highway equipment.

An aeration system was located on the interior of these early vessels to fluidize the cement, permitting it to flow on an 8 to 10 degree slope, at which the tank was tilted when mounted on a small flat bed trailer. In addition, through a special valving device located at the discharge point of the tank, air was continually mixed with cement for the purpose of conveying the product to a distant unloading point through hose and pipe.

Refinement of this original design produced a capacity increase by joining two vessels together forming one double tapered tank with a common outlet centrally located. With increased capacity, this design had appeal to over-the-road for-hire carriers.

Butler at that time, in projecting the dry bulk transportation market into the future, could see the need for equipment that was versatile enough in its capabilities to handle a variety of dry flowable products in addition to those which lend themselves to aeration in order to flow. With this in mind, Butler introduced a pressure unloading trailer having a clean bore payload compartment incorporating a series of steep slope hoppers having outlets manifolded by means of a common discharge pipe. This hopper type pressure trailer is accepted as the latest improvement of such equipment.

Late in 1958 circumstances which confronted the cement industry's Eastern market were responsible for greatly accelerating the general acceptance and refinements to pressure unloading trailer tanks.

At this time, the cement industry was experiencing overcapacity production in the United States. Coupled with this, foreign and Canadian cement was being imported and distributed by truck. This resulted in a very competitive situation among U. S. cement producers. As a result, conversion to truck shipments was accomplished within a matter of months, which contrasted sharply to earlier periods when mills required several years to bring about this change.

Economies plus convenience offered by pneumatic truck delivery to the users of dry bulk products stimulated the demand for this type of delivery in other industries too. Ever-increasing labor rates proved the operation and maintaining of mechanical conveyors, plus down time losses suffered, to be uneconomical. Conversely, pneumatic conveying is recognized today as a means of reducing costs by utilizing truckers' shipping containers on wheels with built-in material handling systems which result in controlled inventories and increased profits.

As pneumatic unloading of trucks transporting dry flowables from New York to Virginia established this type of delivery, the demand also spread like a grass fire into areas never before offering truck shipments. Such a spread continued to grow and expand until today many dry product producers shipping in bulk depend to a great extent on truck equipment for delivery of their product.

To provide equipment to service this new transportation requirement for dry products, a variety of trailer designs appeared on the market in 1959 and continue to appear today.

In Butler Manufacturing Company's analysis, the designing of a pneumatic transport trailer by our engineers must include the consideration of many factors, which are:

1. The system must handle a wide range of bulk products to lend versatility to the equipment.
2. The payload compartment must discharge completely to prevent contamination from one load to the next.
3. The unloading time must be the minimum.
4. The system must be simple to operate without presenting problems for the average equipment operator.
5. The equipment must be safe as a stationary pressure vessel.
6. The equipment must be safe and durable as a highway trailer.

Published data on pressure tanks incorporating pneumatic handling systems is limited. Our approach has been to use full scale testing of systems to gain knowledge of the pneumatic sciences and refine these systems for marketing with our trailers. The most successful is a flow inducing pressure differential system maintained at the outlet, using flow control valves. Rotary air lock valves, which are common to in-plant pneumatic systems, are not considered satisfactory because of weight and necessary drive mechanism.

Only by full scale testing under actual operating conditions have we been successful in accurately evaluating the effectiveness of the equipment in handling various materials, and measuring whether or not design changes result in improved performance.

Variables that would not be present in scaled down testing of small samples must be considered. Such variables would be the condition of the material as loaded. Is this material hot or cold? As it comes off stream, is the drying equipment efficient, or are parts of the load dry and parts damp? Does condensation form on the inside of the vessel? Does the product pack from shock loads resulting from over-the-road hauling? Does high temperature air from the blower cause problems? Is there moisture pick-up as a result of aeration with humid air? Is there any static electricity effect? What is the effect of caking of the product in the trailer tank? These questions are all answered by determining the flowability of the material under actual unloading conditions.

The pressure differential system has proven effective in handling many dry flowables of varying characteristics. Some of these products will fluidize as a result of aeration, and other granular materials do not possess this characteristics. This system is a solution which meets both situations.

To start operation, air is introduced into the vessel along the length of the hopper slope sheets, and is diffused into the product through special aeration equipment. Supply air is divided by a control valve.

Generally, as much air as the material flow will tolerate is introduced into the unit. Free flowing materials require less air assist in the hopper area, and an air balance must be reached to avoid plugging of the system. Air not introduced into the vessel is added to the flow below the hopper discharge valves.

By such a procedure the product particles are mixed with air so that they tend to flow without touching one another, and therefore tend to flow very freely in a conveying stream of air through hose and piping to the storage silo.

The operation of the Butler pneumatic unloading trailer is simple, rapidly stabilized to achieve optimum flow, is not overly sensitive to valve adjustments, and does not require constant attention by the operator during unloading.

The normal unloading procedure is to direct the entire flow of air into the trailer tank. By so doing, the vessel is pressurized and the product is aerated. After reaching a desired tank pressure, a portion of the air is diverted to the unloading manifold connecting each hopper to the unloading hose. Hopper outlet valves are opened individually or simultaneously, depending upon the product, thus permitting flow from the trailer tank to the storage location. There are no moving parts on the interior of the vessel to accomplish unloading. Once the unloading operation is stabilized, constant attention by the operator is not required.

Tank pressure shown on a prominently located gauge remains stabilized until the "clean bore" portion of the payload compartment serviced by each valve becomes empty. When this occurs, the tank pressure decreases to zero, and the outlet valve is closed.

The steep slope hopper design shape of Butler trailers, augmented with an aeration system, produces a combination capable of unloading finely ground talc-like materials as well as coarse granular products with equal ease, achieving complete clean-out.

As an added feature, an anti-slug device joins the vessel to the discharge line ahead of the flow control valve. This function in case of power unit failure to continue product flow by utilizing the accumulated tank air until the product valve can be closed.

The design of the tank vessel as a pressure container conforms generally to ASME criteria, Inter-State Commerce Commission regulations, and Butler policies on pressure vessel design.

The horizontal hopper type vessel does not lend itself to a pure ASME design approach because of the discontinuity in the hopper area. However, our engineers have established the following design criteria:

1. Limit the operating pressure by relief valve setting to 15 PSI. Above this pressure, vessels must comply strictly with the ASME code because of state and minicipality regulations.
2. Use ASME formulas as applicable and design to 4:1 safety factor throughout. This is based on a minimum ultimate strength for hot rolled steel and aluminum, which are the two materials normally used in vessel construction.
3. Across flat panels, incorporate staying system of tubing to control stresses within a limiting range.
4. Test typical weld samples frequently to assure high quality welding. Use as much automatic welding as possible. Approximately 85% of Butler vessels are now automatically welded.
5. Hydrostatic test at 1½ times operating pressure.

The design of the unit as a trailer is based generally on our liquid transport trailer and pressure vessel design experience. Considerations as a trailer are as follows:

1. The design must be light weight without sacrificing strength. We use a monocoque design which utilizes the shell material as the load carrying beam, and does not include any external longitudinal framing. All bending and torsional loads are taken by the shell material. The trailer vessel in steel weighs approximately 5000 pounds, and can carry loads up to 60,000 pounds at speeds of 65 miles an hour. Safety factors in bending under these conditions are approximately 10:1.
2. Road reactions must be transferred to the vessel in such a manner that concentrated stresses are not introduced

which effect the safety factor of the pressure container.

3. Weight distribution must comply with state highway regulations.
4. Unit must be maneuverable and in general have a shape and dimensions that are practical and conform to all the requirements of the Inter-State Commerce Commission and other regulatory bodies.

In the operation of pneumatic unloading trailer tanks, the air source is normally a rotary blower or piston compressor mounted either on the trailer or the tractor, or in some cases located as a stationary piece of equipment at the unloading site.

Trailer mounted blowers are driven by an internal combustion engine of approximately 70 HP capacity. These blowers have an input in the neighborhood of 400 CFM when operated at 2800 RPM and 15 PSI.

Tractor mounted blowers are driven by the truck engine through a power take-off arrangement. In each case the air output for product conveying is similar.

At the time of the recent upsurge in poularity of pneumatic pressure trailers, 4″ unloading piping was established as a standard size for trailers and silo product supply lines. Earlier dry bulk trailers, especially servicing the sugar industry, employed 6″ lines, but even in this field there is a trend to change to the accepted 4″ standard size.

Silo piping can be standard steel pipe, tubing or conduit, having a 4″ I.D. All bends should contain as generous a radius as possible, with 48″ being the minimum. Piping inlets at the storage bin are usually 180 degrees from the vertical entering near the center of the bin.

Dry bulk products are regularly being delivered into storage silos in excess of 150 foot elevation, or 200 foot horizontal distance, without problems. The rate of unloading will vary with the vertical and horizontal distances, and also with the product involved.

Cement, for example, can be unloaded at a rate in excess of a ton a minute when elevated into silos 60 feet high. Coarse granular fertilizers may attain only one-half ton per minute, while light weight flowables will discharge at 1800 pounds per minute.

Not all products are delivered into closed storage tanks. Fertilizer and salt are frequently discharged into grade level or below grade level open bins.

Other requirements imposed on pneumatic unloading equipment include maintenance of strict sanitation involving dusting and venting when transferring edible products. In such cases the storage silo is normally vented back to the trailer by means of return air piping into a trailer mounted filter. From this point the air can be discharged either to the atmosphere or back into the blower, producing a closed air supply system.

Variations in equipment design are also affected by state highway regulations governing allowable gross weights. This is evidenced by the length of trailers considered individually and when coupled with tractors. The most striking difference occurs between East and West Coast equipment.

Originally, due to road conditions, it was necessary to have East Coast trailers short in length and comparatively small in capacity when contrasted to West Coast semi trailer – full trailer combinations stretching out to attain unusually long wheel base dimensions.

In dry bulk product transportation, light density commodities require large cubage to obtain maximum allowable payloads. This accounts for another variation which the trailer equipment supplier must have available to offer the trucking industry to produce transportation equipment capable of achieving economic return for its owners.

Most observers believe the fertilizer industry, in fact the entire chemical industry, offers a potential to the trucking industry far greater than any recent expansions. New demands will stimulate truck equipment development and refinement to meet these needs. As this new concept in the transportation of bulk flowables develops in your industry, it will be a major contribution in cost reduction benefits to both the shipper and the users of fertilizer materials.

CHAIRMAN SAUCHELLI: Thank you, Bob. That certainly was an interesting presentation of the new development. I'm optimistic in thinking that within the next 10 years we're going to see tremendous changes in our industry both in manufacture, and transportation, handling and so on.

We have some time for questions. Who has the first question or comment on this paper?

MR. GRANT C. MARBURGER: We wondered if Mr. Fischer in the type system he was describing it could be made portable in some fashion such as the Butler Company owns? Can you drag that air-lock pressure type equipment down the highway in some fashion using the ammonium nitrate bulk unit described? Any bulk unit, nitrate, or any granular material?

MR. FISCHER: I'm afraid I don't get his question.

CHAIRMAN SAUCHELLI: He doesn't quite get your question, there.

MR. MARBURGER: In the type equipment that utilizes the pressure system of the air lock valve or a suction system, as far as that goes, can it be mounted on a truck or a trailer and then taken down the highway.

MR. FISCHER: Yes, it can. The difference between the bulk truck that Mr. Geisenheyner has described and the system which I described is essentially this: the bulk truck is a batch operation, it must be charged and then pressurized, and the system I described is a particular operation which runs 24 hours a day every day, Saturdays and Sundays.

CHAIRMAN SAUCHELLI: It would be difficult, then, to put it on a truck.

We have a question. The one in the back of the room.

MR. MARBURGER: The point here, I don't recall hearing the price figure of the trucks and the trailers and the three hoppers. What does that cost?

CHAIRMAN SAUCHELLI: Would you mind repeating it at the mike? Up here to the loudspeaker, please.

MR. MARBURGER: The question for both of the speakers on cost, I don't recall hearing cost figures, one on that 40,000 pound unit Mr. Fischer described, what range would that cost, and on those trailers, you say they're 850 cubic foot, 3 bin, 3 hopper, what does a trailer like that run?

MR. FISCHER: The cost of installation of a stationary system, there are so many intangible factors that the rule of thumb I would say that systems such as I described not counting the bulk storage bins would be between five and seven thousand dollars.

Now, if you go farther, you want more capacity, you have different movement conditions as far as installation is concerned, your cost fluctuates accordingly.

MR. GEISENHEYNER: On your semi-trailers naturally they will vary with such conditions as material, such as steel versus aluminum, but as a rough figure they will range anywhere from ten thousand dollars in steel to, say, fifteen thousand dollars in aluminum, depending upon capacity, quantity and what type of air system is furnished, such as an engine driven blower located on the tractor or a tractor mounted blower. But roughly between ten and fifteen thousand dollars.

CHAIRMAN SAUCHELLI: Do we have a comment, question?

MR. TONY G. FRANKENHOFF: What is the lightest density and the most finely divided material that you can handle satisfactorily with this mobile transportation or the stationary system?

CHAIRMAN SAUCHELLI: What is the finest that is handled by either system?

MR. FISCHER: We are handling pneumatically material that weighs one and a quarter pounds per cubic foot.

MR. FRANKENOFF: How fine?

MR. FISCHER: How fine? Particle sizes in the micron range, one to five microns.

MR. GEISENHEYNER: I might add that light density materials obviously require a large cubic trailer to achieve a pay load because for-hire carriers are naturally very interested in how much they're going to get per haul, so that there is a limit to the size of the trailer. Current maximums right now are around 1500 cubic foot in a pressure vessel type of design. However, to answer your question specifically, we have some Butler installations at Cape Canaveral which are approximately 5 pounds per cubic foot.

MR. FISCHER: I might also mention the other extreme. We handle pneumatically, materials weighing 250 pounds per cubic foot, so as long as you can convert the energy of the air to transportation there's no limit.

CHAIRMAN SAUCHELLI: You have been a fine audience this morning. We certainly appreciate your attention given to the speakers and we will stand adjourned until two o'clock and will resume promptly at two o'clock.

(The session adjourned at twelve thirty o'clock p.m.)

Wednesday Afternoon Session, November 8, 1961

The Round Table reconvened at two o'clock p. m., Mr. J. E. Reynolds, presiding.

CHAIRMAN SAUCHELLI: Please come to order. I am sure we all feel more comfortable in this rearrangement that we have had. We will resume our program, and I am sure you will be as interested in this afternoon's session as you were in this morning's, and it gives me pleasure to turn the meeting over now to Joe Reynolds who will monitor the afternoon session.

Joe.

MODERATOR REYNOLDS: Thank you, Vince. First of all I would like to extend my personal welcome to the members of the 1961 Fertilizer Industry Round Table. It is indeed a privilege and a pleasure to appear before you again this year.

The Round Table remains as your meeting and through your gracious efforts we have been able to assemble what we hope will be another successful program. We in your executive committee recognized our responsibility to you to continually search out the subjects of most interest to the production men in the plant and to further this, we want to do our best to assemble the experts and authorities to discuss these subjects.

The biggest problem which confronted your executive committee following last year's Round Table was: what can we do to make the program more effective? The mechanics of putting the program together occupied considerable time and planning. The final program which evolved retains the same basic method of presentation but with many new topics and subjects.

The subject of materials handling seemed like an appropriate one for us, so as a result we did our best to search out the field, search the people who can cover these various subjects and we tried to cover it all the way through.

This afternoon we go into another phase of it, but still closely related to material handling. The subject of mechanical materials handling would not be complete if we failed to discuss scales and weighing. We are often referred to the advancement of the fertilizer industry as one which is vitally dependent upon efficient materials handling equipment to move the hundreds of thousands of tons of materials and finished products through our plants.

Raw materials, dry and liquid, are weighed before they enter the plant. The dry raw materials are weighed into our process systems; the liquids are metered or measured through scale calibrated equipment and the finished products, bulk or bagged, are weighed before they leave the plant. Without a doubt accurate weights are an essential to the profits and the reputation of our industry.

Today we are very fortunate to have with us a representative of the scale industry who will speak to us on the fundamentals of weighing. This next speaker has been with his Association for approximately 16 years. He is familiar with the fertilizer industry, I believe his father was associated with the company at one time. It is my pleasure to introduce Mr. Arthur Sanders, Executive Secretary of the Scale Manufacturing Association.

Mr. Sanders.

The Fundamentals of Weighing

Arthur Sanders

THE Scale Manufacturers Association is especially pleased to be represented on your program. Scale weighing is our business. The fertilizer industry is an important user of scales. The invitation extended to me by your Mr. Albert Spillman was received as a command for performance.

Scale people feel a responsibility to bring about an awareness among business people of the opportunities available through good weighing practices and of the dangers of inadequate scales. All too often it seems to us the scale owner pays too little attention to weighing, which we think may be the most critical operation of the business.

With the hundreds of thousands of weight determinations a good scale will make; the tremendous total value of the products it weighs; the very substantial dollar cost of even small weighing errors; the low cost of good, modern scales and reliable scale maintenance service, the use of inadequate weighing equipment anywhere should not be excused.

The significance of quantity determination by weight to the fertilizer industry should be self-evident. Your industry buys its raw materials by weight. You process by weight. You inventory by weight and you sell by weight. Mistakes or excessive errors anywhere along that line can be very costly in product and money. You handle tremendous quantities of materials, and the use of the wrong scales or of obsolete scales to handle these materials can be costly in man-hours, either reducing your anticipated profits, or placing you at a cost and price disadvantage with well-equipped competitors.

Those facts are elemental to today's alert fertilizer executive. In simple terms, the fertilizer plant must, of necessity, have quantity determination at numerous points from the point of receiving raw materials to the point of delivery of finished product. The scale is the most dependable and the most accurate instrument for determining quantity, and it has been thus for many centuries.

Tools of Management

To put this another way, scales and weighing systems are necessary tools of management, designed to give you the quantity controls and the quality controls which are vital to the efficient operation of the modern fertilizer plant. They can provide you with the protection of your incoming and outgoing quantities and of the quality of your product, all so essential to your profits and stability.

Basically, in quantity controls scales assure you correct receipts on your purchases; provide proper data for your internal accounting for inventories, interdepartmental transfers, taxes, etc.; and can provide you with assurance that you are giving your customers sufficient weight, but not excessive weight. In the matter of quality controls, the scales can furnish you the means of controlling the consistent high standard for your product.

In addition to the quantity and quality controls which are so necessary to your continued well-being, you can, if you will, obtain a very important essential to your business — savings of costly labor. Most any scale can determine quantities within the range of its weighing capacity, but all too often the best type for the particular job is not used. If the wrong type of scale is used, it can be very costly in high-priced labor. Thoughtful investigation and planning, with the assistance of competent counsel from weighing specialists, can go a long way toward eliminating labor waste in scale weighing

If I were asked to make one suggestion about the rather general introduction to this subject, it would be that management in the fertilizer industry develop an increased awareness and consciousness of weighing at every point throughout the plant. And, I'd go another step by suggesting that this active consciousness of the significance of weighing be practiced by all personnel engaged in weighing operations and by supervisors at all levels.

The reason for this suggestion is that it has been the experience of the scale industry that there is a serious consciousness of what weighing means to the company and its customers, an efficient and well-maintained weighing system will be in use. Such systems almost never cost anything because the returns in savings are greater than the cash outlay.

Good Weighing Benefits vs. Bad Weighing Costs

There is an old axiom frequently heard among scale people to this effect: "If it's worth weighing at all, it's worth weighing right." If we stop to think about that principle, I think we must agree with it. The main cost of weighing is not the scale itself, but the cost of materials handling, man hours and process delays. The scales and weighing systems cost only fractions of pennies per weighing.

Actually, over a period of time it will cost very little more to have proper weighing than to have poor weighing; in fact, the chances are that correct weighing will cost considerably less than poor weighing—even may pay handsome returns in many cases. The opportunities for saving pennies per weighing can run into staggering sums, particularly in an industry such as yours where the buying, selling and processing operations require numerous weighings and where you can lose on short weight, overweight, or undetected waste in processing.

You have heard it said, as have we, that the values of raw materials and finished product are so low that it doesn't pay to go to the expense and bother to have and maintain good weighing systems. I challenge that theory on what I think are sound grounds. In the first place, you are handling tremendous quantities of materials so the opportunities for losses on bad weighing have to be tremendous. In the second place, the cost of raw materials to you and the sales value of your finished product are very great, so small losses per weighing can amount to large sums indeed. Consider, if you will, the fact that an error of ½ of 1% in the weighing of $1 million of gold is of equal cost as the same error in weighing $1 million of fertilizer—$5,000 in each instance.

As evidence of large losses which can be sustained on low value materials, let's look at a small example. Suppose a plant turns out 25,000 tons of fertilizers a year and that the value is 2 cents a pound, bagged. If the bags average only 1 pound per hundred overweight, those overweights have cost $10,000. That example can be multiplied by the size of the plant output. That example only touches on outgoing weights for finished product, but how about quantity controls on incoming purchases. These weights could be against you and if you are not checkweighing your receipts, you are taking a big chance of loss on every shipment received. The shipper's loading scales or the carrier's railroad track or motor truck scale may be wrong, or there may be considerable wastage between the shipping point and your plant. You are entitled to receive all the weight that you pay for and if you are not checkweighing those receipts, the chances are that your losses are larger than you think. There have been many cases of huge inventory shortages, but when they are discovered, it's too late then to question the weights of the receipts.

Those examples consider only the area of quantity controls, but how about the matter of quality controls? The quality of finished product is something no plant executive wishes to have questioned. Continued good will is a treasure to all good companies, and the executives are responsible to the company owners for its preservation and improvement. Deterioration of quality or inconsistent quality can be costly to the fertilizer operator, particularly since the states exercise supervision over quality of output.

Quality, of course, depends on accurate proportioning of ingredients, among other things. If the scale weights are not correct, there will certainly be shortages or overages of important and costly ingredients. At this point the weight proportioning system can be costly, either in customer good will or in expensive ingredients.

What Makes Good Weighing

We've talked a good deal about good weighing. Well, what makes good weighing? The elements of good weighing are, first, the selection of a well-made scale or weighing system of good design, proper for the particular weighing job, after careful study of the circumstances by experienced scale people; second, there must be good installation to see that the scale has a fair opportunity to function under proper conditions; third, there should be frequent testing, inspection and maintenance to see that wear and external conditions do not cause the scale to go out of tolerance; and, last, but as important as any, is operation and supervision by capable people who can spot improper weighing practices or unsatisfactory conditions affecting the performance of the scale.

As to study of the weighing job and conditions, in selecting appropriate scales this should be very carefully done at the outset by experienced plant personnel and scale people. You should look to and expect the selection of weighing devices which are the most proper for the particular weighing operation, all circumstances considered.

In the matter of design, there are many features which are well known to scale design engineers. Many of these features are long accepted and well recognized for particular scales, applicable to certain weighing assignments. New design features and new scale capabilities are, of course, being developed all along, and the scale industry has certainly done a great service in meeting the special requirements of your industry and others. The good design engineer must very carefully study the requirements of the particular weighing job and correctly incorporate the applicable features which will best provide the needed sensitivity, accuracy, trouble-free reliability, speed, installation arrangements and other essentials.

A well designed and carefully produced scale may function improperly due to poor installation, through no fault of the scale itself. Good installation is an element of scale operation which can't be overemphasized. Careful consideration should be given to the firm foundation on which the scale should rest, and to the avoidance of the adverse effect af excessive vibration. Space limitations frequently affect the scale features which are to be utilized. Arrangements should be made to avoid load shocks as much as possible, to retain the stability which was designed and built into the scale, and to avoid upsetting the delicate alignments and adjustments.

Frequent testing and maintenance are musts for good scale performance. The scale is the very finest measuring instrument, long recognized for its consistent accuracy and reliability. However, like any instrument or machine, with constant use its parts may become worn and deteriorated. Adverse external conditions such as dust, corrosion, etc., repress the freedom of the working parts. Management can make tremendous strides toward completely satisfactory weighing by becoming scale and weight conscious. One of the significant factors which this consciousness should recognize is frequent testing and maintenance by competent scale personnel.

One way in which every plant can control the accuracy of its smaller capacity scales is to have test weights available at each scale and make your own tests each day or several times each day. In addition to the test weights for testing the full capacity, there should be available small weights of, say 2, 4 or 8 ounces (depending on the capacity of the scale) for testing the sensitivity of the scale. The sensitivity must be tested because, even though the scale may be accurate at, say 100 pounds, if the internal elements have become insensitive, an eighth or quarter pound weight added with 100 pounds already on the platform may not move the indicating element.

For motor truck and other large capacity scales, you may need to call in scale servicemen or the state weights and measures authorities.

Supervision is frequently overlooked. It includes not only supervision of weighing personnel but of the weighing practices, the scale itself, and the conditions under which it is operating. Supervision of the weighing should be by well trained people who can and will recognize unsatisfactory weighing conditions and are capable of taking the necessary action to correct them. It should be to your advantage if the supervisors can be independent of the actual weighing functions. In addition, the weighmen themselves should be skilled in their tasks—they are the weighmasters and if they don't know and carry out proper weighing practices, with complete sincerity, the chances are that your weighing will not be satisfactory.

No doubt these several important elements of good weighing are as well known to you as they are to people in the scale industry. They are so significant, however, that it is well to have them reemphasized. As you well know, good weighing can't be bought merely by purchasing a well designed and carefully manufactured scale, although good weighing can't be had without that first essential. Management can have really fine weighing if it will, and the starting point is for management to become weight conscious. If you have weight consciousness, I have no doubt you will have the kind of weighing which is essential to efficient plant controls.

Small Errors Make Big Losses

The seeming indifference of many processors to their scales and to the weights of the packages which leave their plants is rather amazing. This was well illustrated in the report of a New York county sealer of weights and measures. He analyzed the annual scale error cost of 81 seasonal produce bagging scales he condemned and found that the actual errors on an annual basis came to a total of $543,000, or $6,700 a year per scale. One processor, putting up 1,500 bags a day for 220 operating days a year, was losing $75 a day by putting 16 pounds of product in bags marked 15 pounds. His annual loss was $16,500 on one scale.

Now these illustrations are small compared to the circumstances of the fertilizer industry, where even the smallest producer's volume far surpasses anything which was weighed over the scales the county sealer condemned. The fact that the average error cost of those scales was $6,700 does illustrate the point, though, that the cost of weight errors on unreliable scales far exceeds the comparative yearly cost of owning and maintaining good scales.

We submit that the above examples suggest very serious consideration to careful and frequent testing and maintenance of fertilizer scales; that management and supervision become scale conscious and establish running records of scale tests as the basis of a program of maintenance and replacement of unreliable weighers.

Efficiency Meets Competition

Competition has been called the greatest economic force in America — the life-blood for our growth. Foreign economists and industrialists have given competition the credit for much of the efficiency which has led to our predominance in mass production. In recent years England has enacted laws to bring about more competition by eliminating monopolistic and protectionist practices which have permitted industries to govern themselves. Under their former practices even the most inefficient operators could survive. With these circumstances it was said there was not the driving incentive for improvement.

Not so here. Competitors in an industry must look to their own preservation. American industrialists are always on the lookout for improvements and for cost saving devices to make them more efficient, for better earnings; and to enable them to withstand the rigors of market declines and increased product supplies.

These are facts of business life in this country. We in the scale industry are aware of them, just as you are in fertilizer operations. Waste and inefficiency are costly and none of us can afford to overlook opportunities to curtail them lest they devour us.

One of the things I wish to say today is that weighing is a fertile field for improved efficiency in the fertilizer plant. I believe every plant can reduce its costs and place itself in a stronger competitive position by a careful study of its weighing systems and practices—to be followed, of course, by taking the necessary steps to establish the efficient weighing system you can have if you will to do so. Again I repeat that a consciousness on the part of management about the opportunities to improve your operations through good weighing can pay you dividends far beyond the time, effort, and cost.

Profit Insurance

Reliable and accurate scales can be a tool for management in the fertilizer plant another way—a protective service against weight losses for which there is no insurance available. Fertilizer plants pay millions of dollars annually for insurance against fire and other losses. Losses from bad weighing can be as deadly as those from fire. In fact, while you may or may not have fire losses, you are practically certain to have weight losses unless you provide yourself with good scales and fully adequate maintenance. Even aside from the necessity of weight determinations in your operations, this insurance protection which proper scales can give you meets a definite responsibility of management. An otherwise very efficient operation can become red-ink with bad weighing, and management would be hard put to excuse such give-aways because good weighing can be had if there is an open-minded will to do so.

Scales for Fertilizer Plants

There is a variety of types of scales and weighing systems used in fertilizer plants. The types best suited for the particular jobs and the particular plant depends on the existing circumstances. There can be no pat answer, and there should be no preconceived notions as to what is best needed. Circumstances should govern, and the decisions should be made after consultation with experienced suppliers, and in certain cases consultation should be had with materials handling engineers.

Fertilizer scales can generally be categorized as (1) receiving scales to checkweigh receipts; (2) batching or proportioning scales and weighing systems to correctly proportion ingredients for the mixes; (3) bagging and shipping scales.

It would be presumptuous on my part to try to name all the types of scales used in the above and other weighing functions in fertilizer plants, but to summarize I'll mention some broad types which are typical.

For receiving, depending on the volume and shipping methods, there are railroad track, motor truck, manual and automatic hopper and bulk conveyor scales.

For batching or proportioning, there are automatic and manual hopper scales, bulk conveyor scales, both types usually accompanied by appropriate weigh feeders to regulate the incoming supply to the weigher. Also used in this may be portable platform and floor scales, either built-in or self-contained.

For bagging and shipping, there are predetermined weight type net and gross weigh fillers; portable platform scales; floor scales, either built-in or self-contained for larger capacities; and motor truck or railroad track scales for larger bulk shipments. Also for larger bulk shipments, net weights may be loaded into the vehicle from conveyor scales or hopper scales, manual or automatic, some with net weight arrangement for deducting tare weights, recording gross, tare and net weights and accumulating the totals of all separate net weights.

Principles of Weighing

A fairly new term in the scale industry is regularly being heard; namely, load sensing elements. That term is applied to the weighing elements of the scale. For centuries we have had lever scales, used for weighing just about any load from fractions of ounces to hundreds of thousands of pounds. Then, for a hundred and fifty years or so, we have had spring scales, mostly used in the smaller capacities, but also performing well in capacities of 2,000 pounds or so. More recently, approximately dating from World War II, in practical application are the load cell type of weighing elements. In practical use today, load cells are of the strain gage electronic, hydraulic and pneumatic types. In the strain gage type, the deflection of a small bar of steel in the cell is measured through electrical and electronic means, and the deflection proportional to weight is reflected on the scale indicator, recorder, etc. The weight applied to hydraulic cells and pneumatic cells is also proportionally measured by appropriate instrumentation and reflected on the indicator, recorder, etc.

Indicators and Recorders

In scales and weighing the weight must be indicated or recorded in some manner, or there must be some action taken at a certain weight, as in scales which automatically dump at a certain weight load.

The oldest and easiest understood type of indication is the totaling of the counterbalancing weights resting on the weight platter of an equal arm balance. When the balance is in equilibrium, the load equals the counterbalancing weights and their total is the correct reading.

The weighbeam type of indication is represented by the graduated beam with the poise weight. The weight indication is determined by the graduation at which the sliding poise rests when the balance condition of the beam is reached. Additional counterpoise weights hung from the tip of the weighbeam may also be employed to increase the capacity of the scale within its design limits. In such cases, the weight value on the extra weights is added to the value as indicated by the graduation marking at the position of the poise on the beam.

To improve speed and accuracy of reading weighbeam scales, the over-and-under indicator attachment was developed and has found wide usage. With this attachment, the exact balance condition of the scale beam can be seen quickly and correction made for an inaccurate and out-of-balance condition.

A later development in the indicator field is the automatic indicating dial face. The dial may be the complete clock type dial with graduations around the outer edge of the face, or be a segment dial type indicator. In these devices, a pointer is attached to the force transmitting mechanism so the force of the load will cause the pointer to revolve automatically to the correct graduation, where the weight indication is read. These indicators utilize pendulums or springs as the counterbalancing force.

Another type weight indicator employed with scales is the optically projected reading line. Projection and magnification are utilized to flash the weight reading on a screen. This device, which may be the sole indicator or be utilized as an attachment to weighbeam type scales, insures easier and unmistakable reading.

Remote indication to provide for automatic scale reading at a spot far removed from the scale itself is a development that has been found most useful. By this means records can be transmitted instantaneously to an office remote from the weighing area.

Printing mechanisms are available for the most automatic indicating scales and are usually actuated at the push of a button or the insertion of a weight card. For weighbeam scales the "type registering" system is available to impress on a weigh card the weight record from figures raised on the beam. The poise weight is built to allow the insertion of the weigh card in a slot and to provide a hand grip for pressing the card against the type to produce the weight impression. Not only do the printed records provide accounting tools for the scale owner, but they protect him against false accusations when the weighing is not done in the presence of all interested parties.

Automatic Controls

The load sensing elements of scales permit the application of all kinds of instrumentation, so there is little if anything which the scale and instrument manufacturer cannot furnish to meet the complex requirements of automatic processing. In fact, the scale has been called the "brain" of automatic processing of bulk materials. It can and does trigger a whole host of processing steps, automatically keyed to the weight load sensed by the scale. These include such things as automatic starts and stops of feeders, gates, dischargers, timing sequences, overload or underload warnings and, in fact, the interlocking of all manner of mechanical equipment with the operation of the scale, actuated by its load sensing.

The automatic weighing system comprised of several or many scales may be under the direction of one operator in a control room, nearby or at a distance. Here, the formulas may be set in a wide variety of means for the desired mix, the analog and digital indicators can be observed for proper functioning, permanent recordings of ingredients can be made on charts or tapes, and all types of accounting and inventory records can be arranged as needed.

Automatic weighing seems inherently well suited to automatic or semi-automatic bulk handling and processing installations. The weight sensing devices can always be made to supply signals to a wide variety of instrumentation devices. Integration of automatic weighing with computer control devices is already a reality. As new marvels of industrial control are unveiled, they can be applied to automatic weighing for still greater productivity and improved quality control in bulk materials handling by weight.

We wish to point out, also, that in the same ways that bulk solid materials may be handled, controlled and processed by automatic weighing systems, so can liquids and combinations of solids and liquids. The structures, receiving elements and control devices may differ, but the principles are the same. Actually, in each case they are based on quantity determinations, and the most reliable means man has found for this are weight determinations.

Package Weight Regulations

It seems very likely that most all fertilizer executives have some acquaintance with state and local weights and measures laws, regulations and enforcement. Sealers of weights and measures have jurisdiction over the weights of packages sold or offered for sale and generally over the weighing devices used to put up and checkweigh the packages.

We in the scale industry must, of necessity, keep in close touch with weights and measures regulations and enforcement for the reason that all scales used for determining quanities for buying and selling transactions come under the jurisdiction of weights and measures authorities. Based on this close relationship, we can speak with certainty about a recent trend in weights and measures enforcement to expand and emphasize package weight enforcement. This includes fertilizer packages. In fact, fertilizer has been one of the key products on which enforcement has been increased.

In connection with its sponsorship of the annual National Conference on Weights and Measures since 1905, the National Bureau of Standards published in 1959 a manual on "Checking Prepackaged Commodities." This booklet was prepared primarily as a guide for state and local weights and measures officials, but as was pointed out in its preface, the information presented in the manual can be useful to all commercial and industrial establishments involved in packaging, distributing and retailing packaged commodities. Fertilizer executives who do not have this 27-page booklet may wish to obtain a copy. It can be had for 35 cents from the U. S. Government Printing Office, Washington 25, D. C., by asking for National Bureau of Standards Handbook 67, "Checking Prepackaged Commodities."

Many states have adopted this manual as the package checking procedure for its weights and measures officials. We call your attention to a basic principle to which package weights are expected to conform, which is stated in the introduction to the manual, as follows:

"Variations in quantities of packages are not permitted to such extent that the average of the quantities in packages comprising a lot, shipment or delivery is below the quantity stated, and an unreasonable shortage in any individual package is not acceptable, even though overages in other packages in the same delivery compensate for such shortages."

In other words, this policy says the average of the packages must at least equal the stated net weight, with no unreasonably short package—all this adds up to a trend of official demand for closer tolerances. To avoid violations for short-weight and, at the same time, to avoid excessive give-aways in overweight, this situation calls for good scales, good maintenance, and good weighing practices.

Obviously, the easy way to avoid violations and the probable loss of good will from adverse publicity is to practice overfilling. As previously indicated, 1% overfill on 25,000 tons a year at 2¢ a pound would cost just $10,000 a year. The figures can be expanded to fit a plant of any size. That may seem satisfactory to some, but believe me, it's not necessary to toss away valuable finished product that way, for which the customer is not appreciative and no good will is gained. And, there are some good scale manufacturers who can prove that to you—that excessive overweights are not necessary.

You can have net weight fillers that can produce 2 sigma weights (in Statistical Quality Control terms), or 95% of 100 pound weights, for example, within plus or minus two ounces of perfection. And, these can operate around 20 weighings per minute. Actually, repetitive weighings at such close tolerances would not be a serious problem for scale designers if all conditions were constant. Unfortunately they rarely are, and the errors which various, and most always prevalent, changes or disturbances bring about in the overall weighing act are accentuated as speeds increase.

At twenty 100-pound weighings per minute, the feeding stream must have a rate of at least 50 pounds per second (assuring no dribble speed being possible and allowing 1 second for discharge in a 3-second cycle). That's a rate of about 8 ounces in 1/100 of a second, or 2 ounces in 1/400 of a second. Since 2 ounces is a common tolerance in many commercial applications, this means any change or disturbance which varies the point of cut-off, for example, by 1/400 of a second will cause a bad weighing.

To have speed as well as the accuracy demanded by weights and measures officials, but without excessive overweight give-aways, unquestionably means a better understanding of the essentiality of good weighing. It also means the use and maintenance of more sophisticated weighing devices.

In this matter of packaging, checkweighing should not be overlooked. It is most important. There should be a reliable weighing machine to check on the primary weigh filler, the latter being under very heavy use and subject to all forms of wear, abuse, disturbances, and changing conditions. Mechanical devices do wear and lose their designed performance, just as your automobile does. This should be perfectly obvious to everyone. Checkweighing can be done by spot checking on manual scales, or can be done with conveyor line checkweighers on a 100% checking basis. The trend in many industries is toward 100% checkweighing. An important arrangement with these 100% checkweighers can be the feed-back data and controls for adjusting out-of-tolerance weigh fillers.

Care of Scales

Whether we like it or not, we do have weights and measures controls, and we must live with them. Governments for centuries have exercised such controls, taking the position that the quantities of commercial transactions are "clothed with a public interest."

There are two sides to weights and measures enforcement, and I very sincerely believe such enforcement is of great benefit to the business world. Producers and processors stand to lose a great deal more from bad weights than do any of their individual customers, for the very simple reason that their volume is so tremendous. The repetitive volume of a bagging scale, for example, if multiplied by what seems a small error, can be a very large sum.

Weights and measures inspections of fertilizer scales and of bagged output can help to influence much needed care and maintenance of the scales which may be making thousands of profit or no-profit decisions each day. These impartial inspections can show the need for regular care.

We in the scale industry can commend weights and measures, also, for the influence which their performance requirements have had on the improved quality, accuracy and dependability of American made scales. Their rigid requirements have provided high standards for scale manufacturing, resulting in highly accurate and dependable scales for your industry and others.

Fertilizer plants are rather notorious for the bad conditions under which their scales must function. Naturally, this means they need more frequent and better care to protect your interests, as well as those of your customers. Scale weights can be no better than the condition of the scale. For example, dust and corrosion can gum up working parts, create friction and cause errors.

As previously stated, a scale seldom ever gives any warning of out-of-tolerance performance. It just goes right on functioning with its continuing errors. When there is friction in the working parts, this usually means that more product is required on the weighing platform than the weight shown on the indicator.

A good rule for all scales (except for those of very large capacity) is to have the scales tested daily or several times a day by operators with properly approved test weights. But another good rule is that no unauthorized person be allowed to tinker with a scale, or try to repair it. Scale work is very specialized and should be done only by well-qualified and experienced people.

In discussing the testing and care of scales, it would seem axiomatic that if the tests and maintenance show frequent out-of-tolerance condition, the scale may have reached the stage of unreliability. Its future value may be very questionable. Continuous records of tests should be kept, and if the device is no longer dependable, it's as dangerous to your profits as a worn-out automatic steering assembly is to your life. In both cases, it's time to consider replacement. At that time, consideration should also be given to obsolescence—can the efficiency of your operations be improved with improved features of scales and weighing systems?

Conclusion

The problems of quantity and quality controls of the fertilizer industry are very large, particularly since both quality and quantity are regulated by government on an increasing trend. Modern scales and weighing systems can go a long way to alleviate these problems and provide fertilizer plants with the accurate and reliable quantity determinations so necessary to controls of quality and quantity.

Dependable weights are essential to efficient, low cost, competitive fertilizer operations where purchases, processing and sales are by scale weights. While fertilizer weighing is not the easiest, it can be done with accuracy and reliability, and it can be done in ways to save costly labor. Scales are management tools of efficient control. They can be made to work for the fertilizer executive quite efficiently if you will have it so or. on the other hand, they can work to your disadvantage if they are neglected.

The scale industry is accustomed to difficult weight applications under adverse weighing conditions, and I can assure you that our industry is ready to meet your requirements. We think a great many fertilizer plants can greatly improve on their scales and weighing systems at little or no cost (and probably at considerable actual savings) over your present weighing systems. The scale industry stands ready to serve you.

Moderator Reynolds: Thank you very much, Mr. Sanders. I think we will have time for maybe one or two questions. Who will be first?

A MEMBER: I wonder, Mr. Sanders, if you could comment on the relative merits of scales, both lever and load cells, both as to the maintenance, their life expectancy, their cost and their accuracy, both initially and after a year's use in 25 words or less. (Laughter.)

MR. SANDERS: I don't test these scales myself. I can say this, that the load cell scales are newer and they are developing. Now, load cell scale people tell me that those scales can perform at the one tenth of one percent requirements of the National Conference on Weights and Measures and the National Bureau of Standards for large capacity scale weighing; that is, for inside scales. Of course, at two tenths for outside scales.

The lever scale — the load cell scales have certain advantages and the lever scales will be the first to admit it. In fact, a great many of the lever scale manufacturers are in the load cell scale business as well. There are certain advantages of space and speed and what-have-you in the case of load cells. They are not as well known and not as longtime proven. The lever scale — there is no more accurate weighing device in the world than a lever scale, and it's been proven, but it's had 7,000 years to develop.

I don't know that I've answered your question, in fact, I doubt that there is a pat answer to that question.

I think you will find both types used in the fertilizer industry.

MODERATOR REYNOLDS: Another question? I appreciate your discussion here because we are all vitally interested in scales.

We indicated earlier our reputation is really at stake and I think you have pretty well confirmed that.

We will move along to our next series of speakers.

Prior to continuous processing, most plants weighed or measured liquids in small batch tanks. These procedures were simple and errors could be adjusted between batches, each batch was a new experience. Continuous processing requires the same degree or higher degree of accuracy under continuous flow conditions. One of the first requirements for accurate liquid metering or measuring is to be familiar with the physical and chemical properties of the liquids being handled.

The following speakers will discuss the many aspects of liquid handling. We are fortunate indeed today to have a panel of recognized authorities to discuss handling, transferring and metering anhydrous ammonia and nitrogen solutions.

Mr. Elmer Perrine, Director of Technical Service for Nitrogen Division will perform as moderator for this panel and will introduce the individual speakers.

Handling, Transferring And Metering Liquids

Elmer Perrine, Leader For Panel

Thank you, Joe. I want to take this opportunity to thank the gentlemen who condescended to give of their valuable time and experience on this panel. They are very highly qualified and the difficulty which I had in tracking them down indicates the esteem in which the industry holds these men.

As Joe mentioned, studying the questions that came in to this panel over the preceding months, there is an indication that much of the trouble stems from lack of knowledge of the characteristics of these solutions and anhydrous ammonia.

I think we will lead off with the discussion of the characteristics because from that we will have the other developments and I will ask that we withhold the questions until the end of this panel, for this reason: it is quite likely that questions you may have in your mind stimulated by one speaker may be well answered by the following speaker.

We will start in with Mr. James Lewis of the DuPont Company at Wilmington, Delaware. Mr. Lewis.

Physical Characteristics of Fertilizer Ammoniating Solutions

J. W. Lewis

THIS particular topic has been chosen for discussion at this time in an attempt to answer broadly, many of the questions presented to this panel. Taken as a whole, the questions indicate a need for better understanding of the physical characteristics of ammoniating solutions.

What do we mean by the term "physical characteristics" or, "physical properties," as you may chose? Taking a look at a typical data sheet from any solution manufacturer, you will find a list of various solutions with columns listing the chemical composition and physical properties of each. Under the heading of chemical composition, we find the amount of total nitrogen, free ammonia, ammonium nitrate, urea and water all expressed as percent. This information you use daily in preparing various formulas.

Under the other heading, physical properties, we find three more columns showing the specific gravity, salting out temperature and vapor pressure respectively. These are the properties under discussion today — and in particular, the subject of vapor pressure.

Looking at specific gravity first, this value is used in the calibration of weigh tanks and meters to determine the proper amount of solution in a given formula. In most instances, for a particular solution, it is a relatively constant value over a wide temperature span and is therefore not corrected for small changes in temperature. Since this property does not present a general problem, we will pass this point for the present unless someone has a specific question during the discussion period.

The next property is salting out temperature, sometimes mistakenly referred to as freezing point. Actually ammoniating solutions do not have a true freezing point, i.e., there is no fixer temperature below which a clear liquid suddenly turns to a solid. If we take any nitrogen solution and slowly drop the temperature we will finally reach a point at which the solids present (ammonium nitrate, urea, or both) will start to come out of solution and a few crystals can be seen floating around in the liquid. The temperature at which these crystals first appear, i.e., the salts first begin to come out of solution, is defined as the salting out temperature. At this point, the material is, for all practical purposes, still a liquid and can be handled as such. However, if we continue to drop the temperature, more and more of the salts will come out of solution gradually forming a slush which becomes thicker until at some temperature the entire mass becomes solid.

It would appear then, that we need only to keep the solution at or above the salting out temperature and eliminate all such problems. Actually, there is one other precaution which should be taken and that is to prevent loss of free ammonia, especially in transfer lines and around meters and weigh tanks. Assume for the moment that we have isolated a section of line full of solution during a temporary work stoppage; the ambient temperature is above the salting out temperature. If there is any place in this line where free ammonia can escape, two things will happen which could cause salting out.

1. The loss of free ammonia will cause a rise in the actual salting out temperature.
2. The cooling effect of expanding ammonia will cause a drop in the temperature of the solution.

Should these two points come together, salting out will occur and if allowed to continue can plug the line.

The third, and most troublesome physical property is vapor pressure. Many of the questions presented to this panel concern the transfer of solutions, bubbling in meters, etc., all of which are directly related to vapor pressure. We will consider this property from the practical standpoint of the fertilizer manufacturer rather than confuse the subject with all the theoretical aspects. On this basis, then, we can consider the system of ammonia and water and disregard the dissolved salts.

We all know that ammonia will dissolve quite readily in water. If we have an open container of water, at say 70° F., and slowly bubble ammonia into it, holding the temperature constant, we reach a point where the water is saturated with ammonia. At this point, the tendency of the ammonia to escape from the water is exactly equal to the air pressure on the surface and equilibrium is reached, i.e., the air pressure of 14.7 psi is exactly equal to the push exerted by the ammonia and nothing happens. Now if we place a tight lid on the container to which is attached a pressure gage, we find that the gage would read zero pressure. If, under these same conditions, we raise the temperature, the escaping push of ammonia becomes greater than the air pressure above, and gas begins to come out of the solution and will register on the gage as an increase in pressure. We may, therefore, define vapor pressure as the tendency exerted by a dissolved gas to come out of solution at a given temperature, and it is measured in terms of pounds per square inch on a pressure gage.

The situation with ammoniating solutions is analogous to the above. In general, the solution manufacturer has added an amount of ammonia such that at the usual operating temperatures in a fertilizer plant, the vapor pressure of the ammonia is greater than atmospheric. However, since there are a large number of solution compositions, each with its own properties, you should consult the manufacturer's vapor pressure chart for the specific solution being used.

Now, we may ask what happens if we attempt to drop the pressure above a nitrogen solution to some point lower than its vapor pressure? Taking the curve for solution #2 on the previous chart and assuming its temperature is 80° F., we find a vapor pressure of 7 psig. If we have this material in a closed vessel at this pressure and attempt to vent off any of the gases, we find that the gas leaving the vessel is immediately replaced by ammonia leaving the liquid. This action causes bubbles to form in the liquid portion and rise to the surface. The bubbling will continue until an equilibrium is reached between the vapor pressure of the solution and the external pressure.

This is exactly what happens when you get bubbling or gassing in a meter, i.e., the pressure upon the solution as it passes through the meter is less than the vapor pressure. As a result, the ammonia bubbles out of solution producing an erratic reading.

The only way to prevent this is to have adequate pressure on the solution as it passes through the meter. In order to assure adequate pressure, we must consider the entire system in which the solution is stored and transferred. There are three essential points in such a system which determine how much pressure is needed. They are:

1. Vapor pressure of the solution at the existing temperature.
2. Hydrostatic head, which is the pressure exerted by a static column of the solution equal to the vertical height of the meter above the storage tank. In other words, how high must the solution be lifted to get it into the mixer? As an example, if we have a solution with a specific gravity of 1.1, we find that a column 2 feet high exerts a pressure of 1 psig. A column 20 feet high exerts a pressure of 10 psig, etc.
3. Frictional pressure losses due to flow through the line.

Applying these three points to a specific case, let us assume that we have the solution previously mentioned in a tank car or storage tank from which it is being metered to an ammoniator, thirty feet above the tank by use of air pressure. The minimum amount of pressure on the tank needed to move the solution and prevent bubbling would be the sum of the vapor pressure, the hydrostatic head and the line loss. Or, in this case, 7 psig vapor pressure, plus 15 psig static head, plus 3 psig line loss for a total of 25 psig. (The value for line loss is arbitrary since the actual value would depend upon length and diameter of the line, the number of elbows and the flow rate desired.) Thus, if you attempt to operate with less than 25 psig on the tank, you are certain to have bubbling and erratic flow in the meter. To be on the safe side, of course, you should maintain 30 psig on the tank as a safety factor.

The same considerations exist where a pump is used to transfer the solution to a meter. Here, however, the pump supplies most of the pressure and it is only necessary to supply the desired volume of solution to the pump suction at a pressure higher than the vapor pressure.

In a liquid transfer system such as is found in fertilizer plants, the installation and maintenance of accurate pressure gages can tell you immediately where trouble lies. The gages should be of the diaphragm type recommended for ammonia service, and the purpose of the diaphragm is to prevent salting out in the Bourdon tube which would make the gage useless.

A well designed transfer system would have a pressure gage on top of the storage tank; a thermowell with a dial thermometer in the solution line at the first elbow after leaving the tank; a pressure gage at the pump suction and also the discharge and a fourth gage in conjunction with a bulls-eye in the line between the meter and the flow control valve. The last gage in the system is the critical one. The pressure on this gage must always be above the vapor pressure of the solution if metering is to be accurate. Such a system would save many hours of "downtime" to say nothing of the physical strain on the superintendent.

Because of the variety of installations, the kind and grade of fertilizers made at each and the type of ammoniating solution used, it is impossible to make any but general recommendations as to the best type of transfer system. We can, however, offer the following in summary:

1. Consult the manufacturers' charts for the physical properties of the solution to be used. Find out what the vapor pressure actually is.
2. Have adequate compressed air to move the solution from the storage tank to the pump or directly to the meter as the case may be, and be sure the tank is designed to handle whatever pressure is necessary.
3. Install pressure gages at critical points and keep them in good condition — also a thermometer in the solution line removes guesswork as to temperature.
4. Put the proper pressure on the storage tank before starting up and be sure it is maintained throughout the operating period.
5. Finally, if necessary, consult the technical service representative from your solution supplier.

MODERATOR PERRINE: Thank you, Jim. That parallels the idea that when all things fail, read the instructions.

Jim has given us a very good lead-in to the causes of many of our troubles, and the end isn't served until we find out how do we get out of these troubles, and so we'll consign that problem to Mr. Ben Anderson of the Sincliar Petrochemical Company operation at Chicago.

Ben.

Questions Discussed by Mr. B. T. Anderson

Question 1: Difficulties Encountered in Continuous Metering of Volatile Liquids

THIS subject has been discussed in previous Round Table discussions and I believe it will suffice at this time to summarize general recommendations that will prevent difficulties in continuous metering in both Anhydrous Ammonia and Nitrogen Fertilizer Solutions.

Although there are at least three commonly used methods of metering volatile liquids in a fertilizer plant—a positive displacement meter, a magnetic type flow-meter, and a variable area flow-meter or rotometer — we will limit our discussion to the type that is predominantly used in the industry, this of course being the variable area flow-meter.

The most common difficulty encountered in metering volatile liquids is caused by the vaporization of "free" ammonia in the liquid prior to its reaching the meter, or in the meter itself. Accurate metering of a liquid cannot be accomplished by a variable area flow-meter designed to measure liquids unless the material is in the liquid state and completely free of gases.

In order to prevent this vaporization of ammonia, additional and adequate working pressure must be introduced into the system. This working pressure can be induced by the means of liquid pumps, vapor compressors, heat exchangers, or even air pressure. This working pressure must be great enough to overcome the pressure drop from the tank car or storage tank through the piping system and through the flow-meter. Trouble is most apt to occur in hot weather when an operator does not consider the inherent vapor pressure of the Solution that he is handling. It is also necessary to place the control valve in the system downstream from the rotometer because the pressure drop across this valve may be sufficient to produce vaporization.

Corrosion products or contamination in the piping system or storage tank can also cause metering difficulties. If a small piece of rust or foreign matter becomes lodged on the meter flow, restriction of flow may result with a resultant inaccuracy of measurement. This type of problem is readily spotted in a visual glass-type meter, but is is almost impossible to notice it in an armored roto-meter.

Corrosion of the meter itself also must be considered as a source of difficulty, and periodic checks on the performance of the meter using water, or if possible, the fluid being metered is desirable. The periodic testing of roto-meters is just as important as periodic checks on solid feeders in the fertilizer plant. It is not adequate to just assume that a rotometer is functioning properly—it is necessary to actually make periodic checks.

It should be remembered that a variable area flow-meter is designed to meter a specific fluid at one set of flow conditions. Variations of specific gravity, temperature or viscosity could cause appreciable errors in the meter. Of course, correction factors can be applied to the meter to handle these variables if they are known.

It is also important to keep in mind the accuracy of a variable area type flow-meter — they are accurate to 2% of maximum flow. Quite often accuracy is sacrificed in a production plant because the meters are properly sized to handle the minimum and maximum quantities of fluids being metered. It is suggested that if an extreme range of volume of material is demanded by process that appropriate size meters be utilized even if it requires a separate set of rotometers to handle the minimum and maximum quantities.

The human aspect also enters into the performance of types of meters. It is not adequate that a production superintendent knows and understands the functioning of a particular meter — it is actually necessary for the man operating the system to thoroughly understand the danger points with regard to processing fertilizer. Quite often something as simple as not knowing how to read the float gauge in a meter can cause considerable trouble. Time should be spent with the workers actually handling the meter to explain the various things that can cause difficulty.

Question 2: Methods of Determining When a Nitrogen Tank Car is Empty

THERE are several very good reasons why it is important to make sure that a Nitrogen Solution tank car has been completely emptied. If the Solution tank car is not completely emptied and process is being fed directly from the tank car it is possible that *under-proportioning* of the Solution may be involved, with a corresponding nitrogen shortage in the finished product material and perhaps a resultant "poor conditioned" fertilizer material will be produced. The "under proportioning" may be the result of a faulty metering device. However, so often we predetermine that a tank car of Solution will produce "X" number of tons of finished product grade and as we approach this tonnage figure we watch for signs indicating that the tank car is empty. Quite often due to insufficient air pressure on the tank car at this time we will be convinced that the tank car is empty and we will disconnect and send the tank car on its way. Quite often this "under-proportioning" is not determined until laboratory analyses have been completed or the tank car has been returned to the producer where it is weighed.

"*Over-proportioning*" can also be involved especially if a tank car is unloaded into a storage tank and at the same time process is being fed from the storage tank. Here again a faulty metering device may cause the over-feeding; however, this may not be evident unless an exact running inventory is maintained on the tank. As a result of this "over-proportioning" coupled with not completely emptying the tank car an accumulation of shortages will occur.

I.C.C. regulations require that a nitrogen producer report returned material in excess of 3% of the out-bound net weight and also pay return freight on this product. I am sure that we all can see the importance of this return freight charge. It is quite common that the freight on a ton of Nitrogen Solution represents 10 to 15% of the total "laid-in" cost of the Solution and certainly we cannot afford to pay double freight on a ton of Solution.

So far we have discussed why it is important to completely empty a Nitrogen Solution tank car — now let's discuss how we can be assured that a tank car is empty. Unfortunately when handling a vapor pressure Solution we cannot simply open the dome of the tank car and look inside to see if it is empty. General nitrogen fertilizer solutions are transported in aluminum tank cars of two types — low pressure 35-pound tank cars, or 75 to 100 pound high pressure tank cars. It is possible but quite troublesome to remove the dome cover of a 35-pound aluminum tank car and actually take a look inside; however, this is not a recommended procedure. It is almost impossible to remove the dome of a high-pressure tank car without the use of special equipment.

I am sure that most of us have at one time held our hand or an ear to a liquid line to determine if a Solution was still flowing, or we have watched for the pulsating of a liquid hose to indicate if air was passing through a liquid line. This technique, of course, is not a valid method. Insufficient air pressure on a tank car could very easily produce this effect and there is not an easy way to determine whether the empty symptoms are caused by air pressure or by ammonia gas, if the air pressure on the tank car is at a questionable level.

The most common reason for not emptying a Solution tank car is insufficient air pressure on the tank car. It is very important that an operator knows the temperature and the corresponding vapor pressure of the specific Solution being used. If this Solution is to be transported from the tank car to process, sufficient additional working pressure must be placed on the tank car to overcome the pressure drop incurred from the tank car to process. If the additional working pressure is not sufficient to overcome this pressure drop a portion of the free ammonia in the Solution will vaporize causing inaccurate metering and perhaps even "salt-out" and a false impression that the tank car is empty. Inadequate working pressure on a tank car can also produce uneven sparger distribution in the ammoniator which can, of course, result in poor ammoniation rates as well as poor conditioned product. Most systems transferring Solution from tank car directly to process require from 30 to 40 pounds of pressure above the vapor pressure of the Solution at its corresponding temperature. This pressure should be maintained until the tank car has been completely emptied. Of course, it goes without saying that in order to determine the total amount of pressure on a tank car, pressure gauges must be functioning properly and they must be properly placed in the line.

In order to determine whether a tank car is completely empty it is recommended that a tee fitted with a small valve be placed into the liquid line as close to the unloading riser as possible. As the tank car approaches emptiness this valve can be opened to determine whether Solution is still flowing or whether air pressure from a tank car is now flowing through the liquid line. This is a valid technique only if adequate air pressure is on a tank car thru-out its unloading and it is also assumed that the tank car is mechanically sound.

An examination of Sinclair's records indicates that during the 1959-60 fertilizer season 2.4% of the Solution tank cars shipped were returned to the plant containing Solution. In all cases this Solution could have been removed by the customer. We feel that these figures are indicative of the performance of the ammoniation plants in the mid-western states. Although we have no data available, we suspect that the Solutions moved into the direct application market would indicate a higher percentage of returned product due to less experienced operators, lack of adequate air supply and general maintenance on the equipment used to unload. Quite often when an operator has difficulty unloading a tank car, it is automatically assumed that the liquid standpipe in the car has either "got a hole in it" or the standpipe has corroded away. In my experience we have never found that this was the reason for not unloading a solution tank car. It is suggested that if an operator does have difficulty in unloading a tank car that, first of all, he make a complete check of his own system, which would involve his air pressure, liquid lines, valves, etc., and if he still has difficulty with the tank car, he should then call the producer for further instructions on the proper handling of the material.

In summary:

It is necessary to maintain adequate air pressure on the tank car or tank truck during the entire unloading operation. The amount of air pressure will depend upon your unloading system — the type of solution being handled and its temperature and corresponding vapor pressure.

Secondly if adequate air pressure is maintained during the entire unloading operation, the use of a liquid "bleed-off" connection as close to the tank car as possible will serve as a visual inspection point to determine if the tank car or truck is empty.

Question 3: What Pressures Are Best for Unloading Nitrogen Solution and How Rapidly Can It Be Unloaded Without Waste

THE amount of loss of free ammonia during the transferring of Nitrogen Solutions is dependent upon several factors; the type of transfer system, the rate of transfer, the type of Solution, the temperature, and the corresponding vapor pressure of the Solution.

Although the economic consideration is of concern when free ammonia is lost, many times this is overshadowed by the possibility of complaints from workers or neighbors in the area. One of the most important facts that is quite often overlooked in discussing the vapor pressure of Nitrogen Solutions is that almost always we refer to vapor pressure of a Solution at 104° F. In actual practice Nitrogen Solutions seldom reach this temperature. For example, one of the most widely used ammoniating solutions —450-type—has a vapor pressure of 22# psig at 104° F.; however, its vapor pressure at 60° F. is only 5# psig, and at 80° F. only 10# psig.

The ideal system with respect to ammonia loss in transferring Solution from tank car or tank truck to basic storage would be a closed system, an example utilizing a vapor compressor or pump, to induce "pressure differential" to transfer the Solution. However, in actual practice in most fertilizer manufacturing plants we find the storage tank pressure "bleeding technique" is most commonly used. This "bleeding technique" ranges from completely opening the vapor valve at the top of the tank and making no attempt to hold back pressure on the tank, to a more elaborate system employing a back pressure control valve set to maintain a back pressure on the Solution in the tank above its inherent vapor pressure.

Laboratory test data indicates that if a tank is vented down to atmospheric pressure, the temperature of the Solution is the most important factor affecting the amount of ammonia loss. If the vapor vent line is of adequate size the pressure drops to atmospheric pressure in five to ten minutes and the greatest loss of ammonia usually occurs within the first hour. This data would closely parallel the procedure of completely opening the vent valve on a storage tank and quickly reducing the pressure to atmospheric pressure. A 410 winter type ammoniating solution at 70° F. when vented in this manner for four hours lost only .37% of its ammonia—loss at 60° F. was negligible. However, when transferring the higher "free ammonia" content Solutions, substantially more ammonia is lost when venting down to atmospheric pressure. To minimize this loss, a back pressure should be held on the storage tank. This back pressure should be above the vapor pressure of a Solution at a specific temperature.

In order to reduce this loss to some approximate concrete value, we can set up a hypothetical transfer system and calculate the loss. Let's assume we are transferring 450-type Nitrogen Solution from a tank car into a 22,000 gallon basic storage tank by utilizing 60# of air pressure on the tank car to produce the pressure differential. The temperature of the Solution is 80° F. and carrying a corresponding vapor pressure of 10# psig. This storage tank is also equipped with a back pressure control valve set to hold a "back pressure" on the tank of 35# psig. Calculations indicate that the maximum ammonia loss would be of the magnitude of 200# or 1% of the actual ammonia content of the Solution. In actual practice we find that the ammonia loss is actually less than indicated by calculations.

When employing the back pressure system, the rate of transfer does not materially affect the amount of ammonia loss. The rate of transfer would produce additional ammonia loss only if the ammonia vapors above the liquid were compressed and due to this compression the temperature of the ammonia vapor was increased, therefore creating a pressure increase on the Solution at the liquid vapor interface.

There are several methods that can be employed to prevent this ammonia loss from a storage tank "bleeding technique" from becoming a dollars-and-cents loss or create neighbor problems. If the fertilizer plant utilizes a wet scrubbing system, the storage tank can be vented into this system and quite often the affluent from this wet scrubber can be used for process water. In this case the ammonia loss can be introduced back into the system. Quite often "vapor bleeding" of a storage tank can be accomplished into a 55-gallon drum of water. This essentially prevents ammonia vapors from escaping into the atmosphere and causing neighbor problems. Other methods that can be utilized are "bleeding" of these vapors directly into the raw material elevator—the ammoniator—the underside of the sizing screens – or even into an acidulation scruber system.

Question 4: A Description of Different Possible Transfer Systems for Anhydrous Ammonia

BEFORE describing the different possible transfer systems for Anhydrous Ammonia, it would be beneficial to briefly discuss a few basic facts about liquefied Anhydrous Ammonia. Liquefied Anhydrous Ammonia gas under pressure in a tank establishes a temperature–pressure equilibrium with the vapor about its surface. In other words, its physical state corresponds to some point on its vapor pressure-temperature curve and any physical change that occurs must be along this curve. Also the flow of liquid Anhydrous Ammonia is always in the direction of diminishing pressure – that is true of any fluid.

In order to "move" or transfer liquid Anhydrous Ammonia and at the same time prevent a portion of the liquid Ammonia from vaporizing additional "energy" or "working pressure" must be introduced into the system; therefore, a pressure differential is necessary and must be produced.

There are various ways that this pressure differential can be introduced into the system. The four most common methods are:

(1) The use of an Anhydrous Ammonia vapor compressor
(2) The use of a liquid pump
(3) The use of a heat exchanger
(4) The use of a high vapor pressure inert gas (nitrogen packing)

Each of the four suggested methods have advantages and disadvantages and each application of the use of these four methods should be evaluated relative to the requirements of a specific operation.

Presently the most common method of transferring Anhydrous Ammonia is by the utilization of a vapor compressor. When using a vapor compressor, a source of Ammonia from which to "pull" vapor is a necessity. In the case of transferring from a tank car or tank truck to a basic storage tank, the storage tank itself serves as a source of vapor. When the transferring of Ammonia from tank car to process is desired and no basic storage for Ammonia is available, a small Ammonia supply tank holding from 500 to 1,000 gallons of liquid Ammonia will suffice.

The ammonia vapor compressor functions by "pulling" ammonia vapors from the vapor space in the storage tank – this removal of vapors reduces the temperature of the liquid Ammonia in the tank at its liquid-vapor interface and therefore the pressure of the liquid Ammonia in the tank is reduced. These Ammonia vapors are then compressed – as compression takes place "energy" or BTU's are introduced into the Ammonia vapor. These hot vapors are then returned to the vapor space of the tank car. The heating effect of the vapors plus the ability of the compressor to produce additional pressure by hydraulic action is responsible for the pressure increase on the tank car. This technique is quite often referred to as establishing a "false vapor pressure." In transferring from a tank car or tank truck to a storage tank, the Ammonia vapor compressor has produced a "pressure differential" by first reducing the pressure of the storage tank and then by increasing the pressure of the tank car or tank truck.

The vapor compressor method has several advantages over the other mentioned systems. Perhaps its greatest advantage is its ability to remove residual Ammonia vapors from a tank car or a tank truck after all the liquid has been removed. Generally, there are from 400 to 700 pounds of Ammonia vapors remaining in a 10,000 gallon tank car and a recovery of from 200 to 500 pounds can be accomplished with a vapor compressor before it becomes uneconomical to recover the remaining vapors. A second advantage of the compressor is that it has a relatively low maintenance cost. The major disadvantage of the compressor is that it requires a source of Ammonia from which to "pull" vapors. This, of course, is a major consideration in the initial installation cost. The power requirements of a compressor are also higher than required by a pump to transfer Ammonia at a comparable rate.

The second method of introducing a pressure differential into an ammonia system is by the use of a liquid pump. The pump has the ability to raise the pressure of the Ammonia "in transit" by hydraulic action as opposed to the "vapor pressure temperature" method employed by the heat exchanger method. Many fertilizer plants rely upon a vapor compressor to transfer Ammonia from tank car or tank truck to basic storage, and a liquid pump to deliver Ammonia from storage to process. This procedure allows uninterrupted transfer to process at a pressure and a rate required by the process.

The proper selection of a pump and its piping system to handle liquid Ammonia is very essential. Pumps used in Ammonia service must have a "net positive suction head" to assure that no vapor bubbles will enter into the pump to produce vapor locking. This net positive suction head is easily obtained when the pump is to remove liquid Ammonia from the bottom discharge of a basic storage tank. Usually a 1 to 2-foot positive suction head is more than adequate to overcome the "pressure drop" through the suction piping system. In pumping directly from tank car to storage the "pressure drop" over the tank car must be compensated for by the positive suction head. When designing an ammonia system utilizing a pump, keep in mind that the suction piping in this type of pump is critical—eliminate as much "pressure drop" as possible from the tank to the pump and compensate for the "pressure drop" by a positive head.

The advantages of the liquid pump are high transfer rates and high discharge pressures, low initial cost and relatively low operating costs. The major disadvantage of the pump is its inability to remove waste from the tank car or tank truck at its critical suction piping.

The third method of introducing the pressure differential into an Ammonia system is by the use of a heat exchanger. The heat exchanger operates on the principle of supplying hot ammonia vapors to the vapor space of the tank car which creates a false vapor pressure at the ammonia liquid-vapor interface. Heat exchangers can be either bath or continuous and heat can be derived from electrical source or from steam. A typical heat exchanger system designed to remove liquid ammonia directly from tank car to process withdraws liquid ammonia from one of the tank car's two liquid standpipes. This liquid ammonia enters the heat exchanger where a portion of it is vaporized; these hot vapors are then returned to the vapor space in the tank car to produce a false vapor pressure. The second liquid line of the tank car then is used to transfer ammonia to the process. This system definitely has the advantage of a lower initial cost because no basic storage or vapor holding tank is required and the piping system is greatly reduced. The major disadvantage of the heat exchanger system is its inability to recover residual ammonia vapors from a tank car.

The fourth method of introducing "pressure differential" into an ammonia system is by the aid of high pressure inert gas. Many nitrogen producers upon request will "nitrogen pack" a tank car of ammonia. This procedure consists of introducing a high pressure inert gas — usually nitrogen — into the "vapor space" of the tank car. The pressure on the ammonia tank car then becomes a combination of partial pressure of ammonia and the inert nitrogen gas. As an example, liquid ammonia is loaded into a tank car carrying a vapor pressure of 60# psig. Inert nitrogen gas is then introduced into the tank car until the total pressure is raised to 120# psig. 60# is due to the vapor pressure of the ammonia and 60# psig is due to the inert nitrogen gas. As this tank car is unloaded the effect of "nitrogen packing" will diminish in an exact ratio to the volume of the vapor space in the tank car. As the car approaches emptiness, very little "pressure effect" of the nitrogen will be realized; therefore, if the system has a significant pressure drop, ammonia vaporization will occur. The advantage of this system, of course, is that it does not require an original investment in an ammonia unloading system; however, many times this method does not offer adequate pressure differential to insure that a complete tank car of ammonia can be unloaded to process without the vaporization of some of the ammonia occurring.

Although the vapor compressor has in the past been the most widely used method of transferring Anhydrous Ammonia, we find that the liquid pumps are becoming a favored method of transferring liquid. In the "direct application" field pumps are being used to load nurse tanks in approximately one-half the time required by the vapor compressor normally used in an unloading operation. In manufactuuring plants pumps are being used because of their ability to produce a constant and adequate pressure for fertilizer processing. Also with the advent of atmospheric Ammonia storage by the procedures, the pump will find even greater utility in the future.

Comments

Elmer Perrine

Thank you, Ben, for that very excellent discussion. We didn't realize the magnitude of the load we put on your shoulders with all those questions, but you did a very splendid job on them.

We are seeing more and more that our problems stem from pressure. We found from both Mr. Lewis and Mr. Anderson that by keeping pressure on pumps we'll get them operating, we'll be able to unload the tank car, and be able to handle our metering a little more satisfactorily and maintain the analysis of both the fertilizer and the ammoniatng solutions.

We will have the first slide, please. (Slide 1) You must bear in mind that these slides are, we will call it unfounded assumptions leading to predetermined conclusions, but it isn't quite as bad as that, because we do have some record on performance. These are approximate results on solutions containing 34 per cent ammonia, 60 per cent ammonium nitrate and 6 per cent water, having a vapor pressure of 38 pounds per square inch at 104 and salting-out temperature of minus 52 degrees Fahrenheit is transferred to a completely vented storage tank, the assumption being that air and power temperatures, first column, 100 degrees. Final storage pressure per square inch gauge, zero. Final storage temperature, 48 above, so you get quite a lot of refrigeration there lowering that temperature to solution is 52 degrees.

The loss of ammonia per 100 pounds of solution would be 4 pounds, which would be fairly significant. It would be roughly on the order of 3 pounds of nitrogen and in the final storage total nitrogen would be 47.6. You have lost there from 49, I believe it is, down to 47.6. You've lost 1.4 per cent nitrogen.

The ammonia has dropped from 34 per cent down to 31.3, and the ammonium nitrate has gone up correspondingly to 62.5.

The salting-out has been raised from 52 below up to 34 below.

You no longer have the same solution you put in there. It affects your ammoniation, the amount of sulfuric acid, the amount of ammonia nitrate. You have just gotten a different solution, as some people have found, when they get their analysis back.

Now, transferring this solution with the air and the power temperature at 51 degrees you will have final storage zero, which means you have reduced the pressure to vapor pressure at zero at 51 degrees. Final storage 39. You have quite a lot of refrigeration there.

The loss there is only one pound of ammonia per 100 pounds of solution. You have dropped your analysis of the solution from 49 per cent only down to 48.6. The ammonia still remains very much the same, nearly 33:4 as against the original 34.

Ammonium nitrate has gone up from 55 per cent, or 60 per cent up to 60.7, and salting-out temperature is raised only 5 degrees.

Now when you go over to 96 degrees, we are again approaching somewhat the thing we ran into at 100, there's 4 degrees difference and you'll find by skipping some of the data that you've changed your analysis of the product from 49 per cent down to 48.3, not a significant drop, and you have correspondingly dropped the ammonia from 34. down to 32.7. The ammonium nitrate has gone up to 61.2 and the salting-out temperature has gone up only 11 degrees, from 52 below up to 43. We probably could live with that. We're probably not operating much more close to conditions than that will show.

If you will please give us the second slide. (Slide 2) This is a different solution. We have a loss of ammonium content, 23.8 as opposed to the 34 of the previous one. Ammonium nitrate 69.8 as opposed to the previous 60 and 6.4 of water compound with the 6 per cent of the previous one. 34 per cent nitrogen. Vapor pressure quite low, 18 pounds at 104 degrees as opposed to the 52 pounds of the other. Salting-out temperature considerably higher at 15 degrees and that salting-out temperature is high enouugh that in the operating temperatures around much of the country much change of that will get you into trouble, such as salting-out and significant change of analysis. Responding at 100 degrees with the temperature of the air and the car, a final storage, zero, you will have a loss of 1.3 pounds, of that 23.8 pounds of normal loss, dropping your nitrogen analysis from 44.0 to 43.3, and salting-out temperature has been raised from 15 above to 38 above, which is well within the range of many days of operating temperature.

If you will put 15 pounds back pressure on that car, as Ben Anderson indicated, you will retain practically all those products in there. You will keep your nitrogen analysis up to 43.7 of the original 44.0, you have only lost 3 tenths of one per cent of nitrogen. Your salting out temperature has raised to 26 degrees, still a serious problem.

So I believe we all want to emphasize the need for keeping these pressures up at all points, including while we are transferring. Most of the equipment now has enough strength that we can keep that pressure up to control the situation that we show on these slides.

That is about all I think we ought to dwell on that. You will have a little further treatment of this subject from Mr. Walter Whitlock of the Texaco Company of Chicago. Walter, will you take over, please?

Equipment and Methods for Handling Ammoniating Solutions and Anhydrous Ammonia

W. W. Whitlock

Inasmuch as the assigned topic is entirely too broad to be adequately covered in the brief time allotted, we have chosen, rather, to initiate this phase of the discussion by supplying some answers to several specific questions which have been submitted to the panel by members of the Roundtable.

1. *What is the best way to transfer high vapor pressure solutions?* We have found that the use of air pressure is usually preferred in handling high pressure solutions. When using air, the most important factor is the maintenance of enough air pressure to keep the ammonia in solution at all places in the system where formation of gas could cause trouble. Air pressure must always be higher than the vapor pressure of the solution. For transferring liquids, most operators maintain a pressure differential of 10 to 25 pounds; this differential may be up to 40 pounds in going to process. Special precautions must be observed if a pump is being used in conjunction with air pressure. Centrifugal pumps should be operated with the lowest practical pressure on the pump's discharge side, as volume drops off rapidly as pressure increases at this point. Also, pumps should be located as close to the tankcar as possible to keep the suction line short. In the use of a pump, it should be remembered that the relative vacuum created at the suction side of the pump has the same effect as an increase in temperature would have in the separation

of ammonia gas from solution. Very small amounts of gas can cause vapor-locks. Volume delivered by a gear or piston pump is about equal at various discharge pressures, but the pump may be damaged by excessive pressures. In summary, we would like to mention just a few points: a) Make certain that air compressor is large enough to supply the pressure and volume required; b) Provide for a pressure gauge at the car, storage tank and at other points in the system (pressure cannot be gauged accurately at a given point in the system while fluid is moving past that point rapidly, nevertheless if the gauge is there, it at least gives some indication of conditions; furthermore the flow can be temporarily stopped for a more accurate check; c) Provide for an adequate air governor valve in the system; d) Keep handy the solution characteristics chart supplied by the nitorgen supplier; f) Stay within the limits of permissible working pressures on tankcars and storage tanks.

2. *Why is it permissible to use air pressure to unload nitrogen solutions but not anhydrous ammonia? The atmosphere above both is largely ammonia gas.*

This question has been debated at length for quite some time and is yet without complete agreement. Perhaps it would suffice at this time to consider the practical implications rather than to attempt to handle the theoretical extremes in detail. Simply stated, because of the much greater pressures involved with anhydrous ammonia, it is more simple to transfer ammonia with an ammonia compressor or pump than to provide a large capacity air compressor. From another very practical viewpoint, the exclusion of air from anhydrous systems reduces rust and corrosion problems to a minimum. This is especially important inasmuch as ammonia systems are usually constructed of mild steel or iron which is subject to rust when exposed to air and water vapor. Another practical point to consider, from the safety angles, is the greater hazard involved in making the air hook-up to an ammonia car or anhydrous ammonia tank with the already high inherent pressures on the car or tank. Ammonia, generally considered a non-flammable gas, does have explosive limits of 16% to 25% when mixed with air; however, this requires a very high ignition temperature. The limits and ignition temperature will vary with the presence of hydrocarbons or other contaminants. It is significant to point out that this range can be passed through in an aqua ammonia or nitrogen solution tank as well as in an anhydrous system. The important thing to remember is that any equipment, tanks or lines which have contained ammonia should not be welded without first being thoroughly steamed or washed with water and purged with air.

3. *How do you cope with nitrogen solution that has salted out?*

The salting-out of nitrogen solutions poses similar problems with similar answers whether involving manufacturing or direct application on one hand and winter or summer on the other.

Nitrogen solutions with a high "fixed to free" ratio are an economical source of nitrogen for making high nitrogen grades; however, they require special precautions in handling in cold weather. Even the best operators sometimes have found it false economy to try to use high salt-out solutions in extremely cold weather.

The salt-out temperature of a nitrogen solution has been defined by some as the temperature at which crystals form upon cooling and by others as the temperature at which crystals go back into solution after being salted-out. Our procedure, as described in Journal of the A.O.A.C., Vol. 43, No. 3, 1960, is the former.

The practical question, however, concerns with remedial action after salt-out has occurred. Let us first consider the problems of suspected salt-out in a car after hook-up is made, air pressure supplied and no flow is indicated. The first step is to determine if the salt-out is in the unloading lines or involving the car itself. A hose line can be run over the side of the car and liquid valve opened to determine if there is adequate flow of solution. (Some operators prefer to check flow through outlet valve with a "T" connection bushed down to 1/8" pipe nipple or a 3/16" hole in plugged pipe fitting.) If there is flow, then pipe lines should next be checked. Check first exposed sections and valves for possible stoppage. Backwashing with hot water or steam may clear the lines. Sometimes blowing lines with air is sufficient to clear the obstruction. If the line is badly salted, it may be necessary to clear by probing with a hot-water or steam probe until the obstruction is gone.

If the salt-out obviously involves the car, it may be possible to "back-wash" the stand pipe by pumping in some water through pipe lines to the liquid outlets—the warmer the water the better. In most cases, it may be only the liquid outlet valve or only the stand pipe which is clogged, while the bulk of material in the car is still in solution. In such a case, the pressure can be relieved from the car, outlet valve removed and thoroughly washed with hot water. At this stage, the stand pipe can be checked and probed for evidence of any salt or obstruction. If this pipe is salted, it can sometimes be cleared merely by pouring in several gallons of hot water. Sometimes it is necessary, however, to probe the stand pipe with a steam line or along with introduction of hot water in order to clear. After the stand pipe is clear and liquid valve replaced, hook-up of air and liquid lines can be made for proceeding with unloading. One should make certain that all safety precautions are observed when making adjustments on a tankcar or storage tanks, remembering that the pressure a solution exerts is quite different over a wide range of temperature. If in any doubt whatsoever as to advisable procedure, it would be well to check with the nitrogen supplier for further recommendations.

Material salted-out in storage tank, nurse tank or trucks poses some additional problems. If it is possible to get any flow at all, the best way to bring materrial back into solution is with agitation. This can often be accomplished by continually recirculating material by pump. If salt-out condition is

Effect of Loss of Ammonia from Texaco Agricultural Nitrogen Solutions

Solution	% Free Ammonia Lost	Nitrogen Content of Remaining Solution, wt. %	Salting-out Temp., °F.	Solution	% Free Ammonia Lost	Nitrogen Content of Remaining Solution, wt. %	Salting-out Temp., °F.
	0	37.0	50		0	49.0	Below −40
370	1	36.9	51	490	1	48.9	Below −40
(17-67-0)	5	36.6	55	(34-60-0)	5	48.4	Below −40
	25	35.0	76		25	45.8	—
	0	41.0	10		0	53.0	Below −40
410-S	1	40.9	11	530	1	52.9	Below −40
(22-65-0)	5	40.5	20	(49-36-0)	5	52.3	Below −40
	25	38.6	56		25	48.9	Below −40
	0	41.0	−42		0	37.0	27
410-W	1	40.9	−40	U-370	1	36.9	28
(26-56-0)	5	40.5	−30	(16-58-8)	5	36.6	32
	25	38.1	+20		25	35.1	53
	0	41.4	61		0	40.5	67
414	1	41.3	62	U-405	1	40.4	68
(19-74-0)	5	41.0	69	(16-70-6)	5	40.2	73
	25	39.4	Above 95		25	38.8	98
	0	44.0	10		0	41.4	26
440	1	43.9	12	U-414	1	41.3	27
(24-70-0)	5	43.5	23	(19-66-6)	5	41.0	34
	25	41.6	74		25	39.4	69
	9	44.8	−8		0	43.0	26
448	1	44.7	−5	U-430	1	42.9	28
(25-69-0)	5	44.3	+8	(20-68-6)	5	42.6	36
	25	42.3	+70		25	40.9	75
	0	45.0	−8		0	44.0	1
450	1	44.9	−5	U-440	1	43.9	3
(25-69-0)	5	44.5	+7	(22-66-6)	5	43.6	13
	25	42.5	+67		25	41.8	59
	0	47.1	Below −40		0	44.5	−52
471	1	47.0	Below −40	U-445	1	44.4	−50
(30-64-0)	5	46.6	Below −40	(25-55-10)	5	44.0	−42
	25	44.2	16		25	42.0	−3

extreme perhaps the only way to bring the material back into solution is with added hot water or steam in addition to recirculating. If dilution becomes necessary, use can be made of dilution charts supplied by nitrogen producers which show the change in physical characteristics of each solution at varying rates of dilution. This information is helpful not only in prevention of salt-out in the first place, but in determining the disposition of the material, whether to process or for direct application after dilution is made.

Another suggested way to bring material back into solution or to lower the salt-out temperature is to introduce added ammonia into the system. This will not only create some heat, but will change the salt-out point as well. This system, of course, introduces the greater safety and handling hazard but can be used if all safety precautions are observed.

4. *What is the loss of nitrogen when unloading nitrogen solution and how can this be controlled?* Mr. Anderson has already presented some data and specific recommendations in answer to this question. Supporting these data are some observations we recently made. An analysis of the contents of a 22,000 gallon tank filled using air pressure to move the solution with no specific precautions to control back-pressure showed the product to be "on-test." In another case where the storage tank had an air leak for about 72 hours, the solution showed 0.5% loss of total N, due, of course, to ammonia loss.

It is quite clear from these data that ammonia loss from solutions from tankcars or storage tanks is negligible if proper precautions are followed. The use of storage or nurse tanks with inadequate vents and relief valves or the exercise of frequent interruptions in usage and processing with subsequent relief of pressure each time is likely, however, to cause difficulty with salt-out. The attached chart shows the effect loss of ammonia on salt-out of various nitrogen solutions.

Another factor influencing salting-out characteristics of solutions is the type and amount of corrosion inhibitor used. In comparative tests on such solutions as 450 (25-69-0) in mild steel piping systems we have observed after only two days almost complete line plugging with uninhibited solution and practically no ill effect in solution with our regular inhibitor. It can be concluded from our tests that non-inhibited nitrogen solutions will salt-out or form deposits in ordinary iron pipe at temperatures well above the normal salting out temperatures. This can occur even where there is no leakage of free ammonia from the system. The deposit formation is probably due to the very extensive corrosion which takes place with the non-inhibited solutions as evidenced by the large amount of iron corrosion products (reported as 30% Fe_2O_3 and 70% NH_4NO_3) present. The corrosion which takes place evidences two effects. The first is a reduction of the free ammonia content which would itself increase the salt-out temperature of the solution. Another factor would be the formation of voluminous iron precipitates which would aid in promoting salting out of the ammonium nitrate.

MODERATOR PERRINE: Thank you, Walter, for your excellent treatment of some of our very severe problems. Don't let some of these statements mislead you, we have found in one case, I'll admit quite a wild solution, the first one we showed, the 34 per cent ammonia, I believe it was somewhere around 3,000 pounds loss of ammonia based on the analysis from the grades that we had made and it checked fairly close with the figures that we had up there, so these losses can be very severe, particularly in wild solutions.

We had hoped to have a discussion on corrosion and the manners of approaching the problems by a couple of gentlemen from the Haveg Company. As Walter mentioned, corrosion can have far reaching problems beyond just the mere destruction of materials and equipment, but we are going to have to forego that luxury, but on your seats was a note that the two gentlemen, I think Mr. Hammill and Mr. Mampe, of the Haveg Corporation will be very glad to discuss those problems with anybody in the Statler-Hilton Hotel suite 2-401 and 403 from five o'clock until midnight, I guess, tonight.

We are sorry that we're being pressed for time that way and I think we'll turn this thing back over to Joe, but I want to certainly thank you gentlemen for the tremendous amount of work you have done. I am glad we did provide some escape hatches for them. If there are a few questions, I think they would be willing to answer them, if you stay close to the door.

MODERATOR REYNOLDS: I hate to cut this a little short here but we are running out of time. We do have another topic to cover. We are really appreciative of the effort and time that went into the preparation of this discussion. As a matter of fact, all of the speakers and all of the talks that have been presented have taken a lot of time. The subject that we just finished I think has been hit in several other sessions, but this is one that really tried to wrap the whole thing up. I think it took some excellent preparation. We sure appreciate it.

Continuing our theme of materials handling and specifically liquids, we must move along to the field of the storage and handling of phosphoric and sulfuric acids. Although this subject is not new to us, neither are the problems new. Recognized advancements have been made to reduce the headaches accompanying the handling, storage and movement of these acids. However, questions still remain as evidenced by the replies to our questionnaire that was sent out in the spring.

Our first speaker, Mr. Tom Martin, Director of Tech Service for U.S.I., will answer the questions related to phosphoric acid.

Materials Handling Phosphoric Acid

Tom E. Martin

Thank you, Joe.

These questions read as follows:

What is the most frequent problem that recurs in storage and handling of phosphoric acid, wet process phosphoric acid?

The second question:

The shipping, storage and handling of phosphoric and superphosphoric acid?

The third:

What has been the experience in storage of phosphoric acid in concrete?

Fourth:

What is the status of use of corrosion inhibitors in phosphoric acid?

I think we might avoid coming back to some of the answers, or some of the same subjects by trying to cover these all at once. In the program, as you have it, we have a heading, Tank Construction, and we are talking about storage here. Some of the things I am going to say will be my own opinions, as a matter of fact, most of them will be, and my opinions, as most people's, are certainly open to discussion. I invite discussion or correction. I am sorry we do not have as much time here as we might have had.

The long time accepted material of construction for tanks for phosphoric acid is rubber lined steel. This construction, with rubber or other inert material bonded to the carbon steel, is very satisfactory.

There seems to be very little difference in suitability of the various rubbers: natural rubber, Buna rubber, or GR-S rubber, butyl rubber, neoprene, all seem to be more or less equally suitable as regards corrosion, if you want to call it that, life of service.

Cost, I think, should be the guide. Ordinarily the available lining and curing facilities that the fabricator has will determine the cheapest material to use for the lining.

If a tank is to be field erected, you may be forced to use one rubber over another because certain curing methods, which are possible only in autoclaves in the fabricators' plant, can't be used in field erection.

The size and shape of the tank is sometimes dictated by the manufacturer's curing or autoclave size.

Filed erection is, of course, expensive. Sometimes you may be able to buy shop manufactured tanks of smaller size, more of them, and get the same volume of storage as cheaply, or almost as cheaply, as through field erection of tanks.

Several cautions are necessary on rubber-lined tanks. The maximum temperature is ordinarily limited to somewhere in the range of 160 to 190 fahrenheit depending on the type of rubber used.

Elemental phosphorus is frequently found in trace quantities in furnace phosphoric acid, not in wet process acid. This can settle and accumulate in small quantities in the bottom of a rubber-lined storage tank. Then, if and when the tank is drained and air gets in contact with the phosphorus, you get a fire burning to form phosphorus pentoxide and a lot of heat and you can damage your rubber lining, as well as possibly incurring other hazards. The phosphorus, of course, ignites spontaneously.

A rubber-lined storage tank, of course, must not be used in certain other services, strong sulfuric acid.

Loose liners in steel or wood tanks have been very popular for some years, particularly for small installations where low investment is of paramount importance. These tanks are not as rugged and serviceable as tanks with bonded liners, but they are very much cheaper. They are more suitable for furnace phosphoric acid than for wet process acid where solids may accumulate in the bottom of the tank and require removal.

Where small tonnage throughput demands a cheap installation, this type of construction has a definite place, particularly if use is intermittent.

The opinion of people who have used such tanks appears to be somewhat variable or divided on the usefulness of such tanks.

Concrete tanks have been used. I can't speak of our own experience on the corrosion, if you want to call it that, of concrete in phosphoric acid service. I think there are people in the room who can. Western Phosphate people, perhaps, can tell us about this.

I understand that concrete tanks are serviceable and that a special concrete is required for corrosion resistance. Pre-stressing of concrete is very desirable, because of course concrete is most serviceable when it is under compression.

From the nature of the beast, I think concrete tanks should be used for a large installation only, and should not be considered for a small storage problem.

If you buy a concrete tank, be sure your supplier understands the type of concrete tank which is used for storage of water, and there are a lot of such installations where weepage or seepage of water through the pores of the concrete is allowable in relatively small quantities to the outside of the tank. Be sure he understands that this is not allowable for phosphoric acid. This is not as foolish a statement as you might think.

It is possible to line concrete tanks with other materials, copper and other materials. However, the cheapness of concrete as a material of construction for phosphoric acid storage is dependent on the lack of any other lining material required.

In large storages concrete tanks can be and are cheaper than lined steel tanks, but I don't think this is so for the size of tank used in most fertilizer plants.

Again, I should repeat that some of these statements are opinions of mine, rather controversial, some of the tank manufacturers might take issue with me on these statements.

Other materials suitable for storage of phosphoric acid. Stainless steel, the austenitic stainless steel, the 300 series stainless steels, of course, are very suitable, they do corrode slowly, they are much more expensive than the other materials we have been talking about. In special cases, particularly of high temperatures which must be withstood, stainless steel might be considered.

It appears that fiberglas reinforced epoxy materials will now be available in larger sizes than previously, but still in rather small sizes with regard to storage.

So far I know nothing against the use of this material of construction. It seems to be very suitable.

As regards problems. I am asked here, "What's the most frequent problem?" I don't know what the most frequent problem is, but perhaps the most troublesome problems connected with the storage and handling of wet process phosphoric acid are deposition of solids, and, a second problem, deposition of a second kind of solids. The first kind of solids are iron and aluminum phosphates in gypsum which come out of solution on prolonged standing.

The second problem which is paralyzing, if it occurs to you, is the deposition of frozen phosphates out of solution in phosphoric acid. We have had this happen. If you take a sample of phosphoric acid, whether it be furnace phosphoric acid or wet process acid, in the laboratory and cool it down to any reasonable temperature, 20 fahrenheit, zero, minus 20 fahrenheit, minus 80 fahrenheit, you don't get any crystals. It doesn't freeze, and yet in use in large containers there have been cases where half or more of the contents of the tank have suddenly crystallized. Of course, the crystals form and drop to the bottom of the tank. We have tried cooling with agitation, hoping this would knock down crystals; it doesn't. We tried mixing in quantities of various other materials, other than phosphoric or phosphates: crystalline materials, brittling materials, dust, everything that you might hope to seed the phosphoric with, nothing comes down.

Almost all of the ordinary methods of encouraging seeding or crystallization of a supersaturated material have been tried and you can't get crystals down using any of them. The only means we have found which makes it possible to bring down crystals, and this, by the way, is crystals of the hemi hydrate, H_3PO_4 and one half H_2O, or $2HPO_4H_2O$, is to agitate a thin layer of phosphoric acid in the cold with a jet of air which causes a degree of evaporation of moisture, of water, from the acid.

Now, all along here I have been talking about phosphoric acid of ordinary strengths, 75 per cent H_3PO_4 roughly or 52, 52-plus per cent P_2O_5, 54 per cent P_2O_5, rather.

If you evaporate this a little bit, then in the cold you get crystals now, and these crystals act as seed crystals, so that if you ship a truckload of phosphoric acid and the flange through which the truck was loaded is wet with phosphoric acid, as this truck drives down the road with the breeze blowing on it, the dry breeze of the winter, a cold winter day, there will be enough evaporation occur in the few drops of phosphoric acid on that flange or in the connection of that flange by a valve to the tank, the tank truck or tank car. So that tiny crystals will form.

Then when you might unload through that same nozzle, and this is particularly true of tank trucks or tank cars, a few of these tiny crystals are carried into your storage tank. It only takes one such crystal and the whole tank can crystalize on you, so that it's very important to be sure when loading or unloading phosphoric acid that the loading and unloading nozzles are washed off thoroughly. If you can use water in the winter, well heated, thoroughly, so as to destroy any trace quantities of hemi hydrate crystals which have formed.

As regards corrosion inhibitors, I have no knowledge I can talk about of the use of corosion inhibitors in phosphoric acid.

Superphosphoric acid, it's storage and shipment, I much prefer to leave to the people who made it and handled it in quantities.

Other problems which have occurred in the storage and handling of wet process and furnace phosphoric acid, perhaps the most important is the high viscosity which occurs in cold weather, when the temperature is low. The high viscosity results in a very high pressure drop under flow. For any given flow, the pressure drops through a pipeline of given size and given length is very much greater when the viscosity is higher.

This means that more pressure is required to get the same flow, or with the same pressure you get a much lesser, much smaller flow.

It also happens that at high viscosities centrifugal pumps which are very commonly used for handling these materials lose efficiency both with respect to the head they will put out and with respect to the efficiency, the power efficiency of the pump.

This may help in one respect in that with a very low efficiency a centrifugal pump converts in tremendous proportion with the energy input by electric motor or other drive into heat which goes chiefly into the phosphoric acid, which is then of lower viscosity for driving through a pipeline.

Centrifugal pumps are, I think, still the most popular pumping method in use. Piston displacement pumps, by and large are not very suitable for handling material with a considerable soils content, such as wet process phosphoric acid. They wear out too fast. I don't like to use specific product names but there is one such pump which doesn't seem to wear very fast. The Moano Pump seems to have given good service over a period of years. It's an expensive pump, but it does an excellent job.

Materials for the construction of pumps: stainless steels like 316, 17 or any of the higher stainless materials put forward by the various pump manufacturers.

Piping. Rubber hose is excellent for piping. Rubber lined, steel pipe, saran-lined steel pipe, a number of lining materials are possible. Stainless steel pipe is quite good. Plastic pipe of various kinds is in use and where cheapness is very important, I would agree to or condone its use. Where the daily operation over a long time is concerned, I believe that plastic pipe should be avoided. I've seen accidents occur due to breakage. Most of the plastics in use are thermoplastics. I have seen cases where the pipe was accidentally heated, heated by being in contact, for example, with a centrifugal pump which was operating at very low flow or at no flow with the pump shut off. This doesn't damage the centrifugal pump any, but the material in the pump does heat up and the plastic pipe in contact with the pump can also heat up.

I think that's it for today. Thank you. (Applause.)

MODERATOR REYNOLDS: Thank you very much, Tom.

We have one more speaker to conclude today's activities. The subject is relating to handling and storage properties of sulphuric acid. Our good friend Frank Nielsson last, but not least, will discuss this subject.

Materials Handling Sulphuric Acid

Frank T. Nielsson

I always get worried about these meetings because in essence I know nothing new. All I can do is go over the same ground year after year and hope that some day somebody will remember some of the things we have talked about so that when I go out to the plant I don't see the same damn thing over and over and over, and it's nothing new.

(Laughter.)

Actually. Each year the committee has to make decisions, I guess, as to whether this is going to be an informal type meeting with questions from the floor, or will this be a real super-duper, high technical meeting with professional papers being delivered, and when the letter came up and said, "Will you tell us what kind of pump you use in sulfuric," I said, "Sure, I'll do that." I see that the thing has broadened into a lot, so that now all I have is gimmicks and odds and ends of things to talk about.

Regarding acid pumps, I saw a boy hauling a crab once out of the water with a fishhead and I asked him what kind of crab it was, because I had never seen any and he told me it was a wild one—

(Laughter.)

—and I could tell you that you could use an acid pump, and then that's where we are. This is not a paid commercial, but it just so happens that for handling acid to granulating units we use the duriron, one and a half to one, model DSTUB60; it costs about $306 less motor.

On the Chamber plant down south we use a duriron D23RD for acid recirculation, 5 horsepower, 1750 rpm, 140 gpm with a 60 foot head. It's an iron frame, the impellers last two to three years, the bowls and covers last four to five years.

In acidulation, we use a two by one and a half Dormet-20 pump, 200 gpm. This one installation happens to have about 400 foot of horizontal run and 40 foot of vertical run, so we're talking about 10 horsepower.

We have found that Dormet-20 gives excellent resistance 60 and 66 acid as long as temperatures are in the 60 to 150 F range. When you get above that, the pump goes to pieces in a hurry. We have had remarkably good luck with LeBour L-55, on 98 per cent acid at very high temperatures, and we want to try some of these pumps on regular acid.

Regarding piping, most people use mild steel for over 60, lead for below 60. We have had an unusual amount of luck despite the phosphoric acid experience in going to PBC pipe. We have used it for furnace acid, we've used it for wet process acid, we are using it for 60 baume acid, we are using it for solution; since it's high impact PBC, we're getting better results out of this on 60 acid to acidulation than we did with lead pipe. So, that's all I know about that.

One thing I wanted to warn you about, because one way you become an expert, I guess, is by making a lot of mistakes, and we have learned the hard way that if you have an acid pump, pumping sulphuric acid into a continuous system like granulation, you had better put a bypass on it. We have now standardized by putting a simple open line with no valves in it from the pump discharge back to the tank, let's say it's a half inch iron pipe. In my early days I was a real big shot engineer and I put in one of these real tricky stainless steel back pressure gages or valves, and somebody up at the granulating unit cut off the flow of acid and I happened to be walking by—this happened to be a Willoughby pump — so they had an open suction box on it and I saw smoke coming out, and this pump relief valve had not opened, and this 66 acid becomes so hot that it came to a boil, and we took the pump apart and the 8 inch impeller was down to about two inches.

(Laughter.)

So you see you learn the hard way.

Just to touch on various subjects, the solutions people surprised me by not saying that you've got to have a backpressure valve or a check valve on the air line to your solution cars. I don't know why this is something that you have to tell superintendents. If they don't put check valves on, the ammonia gets into their compressors and ruins the compressors and they really won't believe you that the ammonia is going up the air line until finally the phos acid supplier says. "What's this white deposit I've got in these tanks you keep returning to me?" And you tell the superintendent. "This is ammonium phosphate from the ammonia that has been in the air lines." So finally he puts in a check valve and the troubles are over.

I have one slide to show chiefly because this is a pet peeve of mine. Years ago the pump people used to go to a lot of trouble and expense—this is just a cross section of a URCO type of pump. The only reason I am showing you it is to show the lantern plan in there, because one thing that everybody seems to forget, and we're talking about pipe pumps now, not mechanical seals, but where you have the locating shaft entering the pump you have got to provide some means for the shaft to rotate, you have got to provide some means to keep the fluid from leaking out, because the whole pump case in under pressure.

So you have a stuffing box and in it you put various types of materials to keep the acid or water, whatever is in there from leaking out, and this material has to be lubricated. This is something that people don't realize. You've got to lubricate it to keep it from becoming so hot from the heat of rotation that all the greases inside rub out and you have nothing but burned asbestos, after all.

With normal pumps, people who pump ammonium nitrate, I have seen this in any number of plants, they use — you can't use grease on ammonium nitrate, they don't want to take a chance on adding water where the grease seal is shown, and when they stop the pump some solution leaks out, the ammonium nitrate crystallizes and they start the pump up again and the ammonium nitrate acts as fine sandpaper and bingo, no packing. You'll see any number of these solution pumps operating with great big gobs of solid ammonium nitrate around the packing line.

I think the simple approach would be if people would buy a little rotometer type or purge-meter type rotometer to put on the water line to a solution pipe or to a phos acid pump because you are supposed to leak about one drop a minute. In the old days the pump people used to give us a lot of good help on stuffing boxes. They haven't done it in recent years, apparently.

To make sure that you're getting one drop a minute out, you never know how much is going in, unless your packing is in good shape, and people who make fluo silicic acid find out that where they're making 26 per cent fluo silicic acid, and all of a sudden they're making 5, and they tell you it's only dripping one drop a minute, but they have been putting in new packing all the time, they have never taken out the old packing, the lantern plan is clear up in front, the water that they are forcing out is trying to go backwards through six layers and goes forward through one, and all the water then is going inside.

If they had a little purge type rotometer they could actually meter the water and know what is happening because you do have to have it if you don't want to drip acid out, because your pump goes. So water is the best all-around sealing liquid for most of our use. When it comes to sulphuric acid you can't add water, because you're going to generate heat, cut down on the acid strength, corrode all your shafts, so grease is the normal sealing agent.

This pump happens to have a specially spring loaded type gadget, you unscrew it, fill it full of grease, put it back on and the spring slowly keeps feeding grease to the system.

In most plants we take out the patented deal and get one of these grease applicators that you see on top of a Nordstrum valve, put a piece of stick lubricant in, come by once a day, give it a screw, there's grease in there to run and packing will last with continuous operation in a chamber plant 60 degree acid for a whole year. So it can be done, if the work is done right.

I have just one remaining problem, which is a problem of mine that maybe some of you can solve. It seems that as you store 93 acid, you pull it out of a tank, you keep bringing in atmospheric air, and the moisture in the air then cuts, dilutes the acid at the interface and you get a weak acid solution and after, five, ten years you'll see most of these steel storage tanks with a line around them and you'll build a new one, and some of these tanks go up to 20, 30 thousand bucks.

I have had the idea that if you got one of these dual silica gel units, with activated silica gel in it, put it on the air inlet to a tank, as the pump pumps out acid bone dry air is coming out and, of course, when you are filling the tank you've emptied the acid so you don't worry about it.

I know these tanks are — you use one until it becomes saturated with water vapor, it may have electrical elements on it, you can boil out the water and go on to the other one. I wish the silica gel people would come up with a unit that we can use on sulphuric acid storage tanks for that purpose.

Thanks. That's all.

(Applause.)

MODERATOR REYNOLDS: Thank you very much, Frank.

I think we'll have time for a couple of questions, miscellaneous questions here for any of the speakers. Does anybody have a real urgent question?

(No response.)

I think we will move along then. We sure want to express our appreciation for your sticking with us this afternoon. This has been over three hours. Your attention has really been well received.

I am going to turn the program back over to Dr. Sauchelli.

Thank you very much.

(Dr. Sauchelli assumed the chair.)

CHAIRMAN SAUCHELLIS It has been marvelous the way you show your interest and appreciation. You must know that these men put in a lot of time, they're busy men, but they have put in a lot of time to prepare these papers and to make these presentations, and so your rapt attention is your "Thank you" for their hard work.

The meeting stands adjourned until nine thirty in the morning.

(The meeting adjourned at five fifteen o'clock p.m.)

Thursday Morning Session, Nov. 9, 1961

The Round Table reconvened at nine o'clock a.m. in the State Room of the Mayflower Hotel, Washington, D. C., Dr. Vincent Sauchelli, Chairman, and Mr. Al Spillman, Moderator, presiding.

CHAIRMAN SAUCHELLI: Good morning, ladies and gentlemen. We have a very interesting program for you this morning, and I am going to turn the meeting over to Al Spillman, your Moderator, and he will tell you more about the setup of this session.

Materials Handling—Bags

MODERATOR SPILLMAN: Good morning, gentlemen, and welcome to our 1961 Annual Fertilizer Industry Round Table Meeting. The timely topics we are discussing here during these two and a half days sessions were finalized by your Executive Committee after full analyses from approximately 175 suggested ideas and questions you, the membership, sent to us.

On behalf of your Committee, many thanks to all of you for your splendid help and response.

The theme for our meeting, Materials Handling, coincides with most of the questions you wish to have answered. Our speakers assigned to lead each discussion are highly qualified for their training and experience. Our Round Table has progressed more each year because of our membership freely exchanging information on all phases of fertilizer manufacturing technology. I am sure our future Round Table Conferences will continue successfully because our membership is mutually interested people who volunteer to help and accept responsibilities when called upon.

The technology of our fertilizer industry during the past decade has advanced very rapidly with many improvements in all phases of operations. Undoubtedly we will have more improvements in the near future.

I have worked very closely with a number of raw material producers, nitrogen, phosphate and potash, and from my observation they are doing an outstanding job in the field of research to improve their respective products to supply the quality of materials we require in our formulation program.

Demands for higher analysis fertilizers are on the increase, granulation of mixed fertilizer tonnage is increasing, the use of phosphoric acid in mixtures is increasing, ammonium phosphates are becoming more plentiful and are used in larger quantities in mixtures of conventional, semi-granular, and in blending. All of us have a tremendous responsibility to keep abreast with the future forward innovations in fertilizer technology.

It has been my pleasure, gentlemen, to be part of the Executive Committee during the past year, it has been a challenge and I appreciate all the cooperation many of you members have given our committee.

To start our program off this morning, we continue with the theme Materials Handling and our subject is Packaging this morning.

The use of paper bags for fertilizer packaging, the use of various types of bagging equipment for storage, truck or car, are indeed very important phases of our operations. The discussion on bags will be handled by a committee consisting of Mr. Frank Pocta, Executive Secretary, Paper Shipping Sack Manufacturers Association; Mr. William L. Shoemaker, International Paper Company; Mr. Robert J. MacDonald, Bemis Bag Company; and Mr. John H. Dively, St. Regis Bag Company.

The discussions will cover sack construction, types and uses, open mouth versus valve type bags, pasted versus sewn type bags, moisture barriers.

We will have a package review and also a review on palletizing and stowing cars and trucks.

I shall now turn this part of the meeting over to Mr. Pocta.

Frank Pocta

Gentlemen: It is indeed a great privilege for us, representing the Paper Shipping Sack Manufacturers' Association, to be here with you today.

For the past 28 years, members of the Paper Shipping Sack Manufacturers' Association have expended every effort in engineering, research and development toward the achievement of Multiwall Packaging which would provide American industry with the highest standards of protective packaging at lowest initial packaging costs.

The physical characteristics of Multiwall Paper Shipping Sack Constructions offer the Packaging Engineer a versatile container with unlimited possibilities for applying exactly the right amount of strength and with the added use of specially treated walls, the exact type of protection needed to assure the preservation and safe delivery of a wide variety of products. In addition, the fresh, clean surfaces of Paper Shipping Sacks, printed in brilliant modern colors, provide a dynamic advertising medium for brand identification and other attention arresting copy which the shipper may wish to emphasize concerning his product.

Paper Shipping Sacks are flexible containers, constructed of from one to six walls of shipping sack papers made to rigid specifications, often in combination with special coatings, laminants, impregnations or other treatments, depending upon the type and degree of protection required for the product shipped. And for the packaging of some types of products, we are incorporating within multiwall constructions, barriers of free film sheeting, polyethylene tubes and pouches.

The Technical Committee of the Paper Shipping Sack Manufacturers' Association has for many years contributed greatly toward insuring uniform properties in the papers and sack closures produced by this industry.

In the year 1960, our industry produced over two billion seven hundred millions of Multiwall Sacks for the packaging and shipment of approximately four hundred different products varying greatly in density and physical characteristics. Members of the Paper Shipping Sack Manufacturers' Association produced approximately 90% of this volume, of which

32.45%	was for the packaging and shipment of Agricultural and Food Products
18.28%	for Building Materials
38.88%	for Chemicals and Drugs
7.97%	for Minerals
2.42%	for Miscellaneous Products
100.00%	

A breakdown of 1960 statistical data by types and capacities of Multiwall Sacks for the packaging and shipment of Mixed Fertilizers is as follows:

18.81%	were Sewn Valve Type
63.89%	were Sewn Bottom Open Mouth Type
17.00%	were Pasted Valve Type
0.30%	were Pasted Bottom Open Mouth Type
100.00%	

Multiwall Paper Shipping Sacks produced in the year 1960 were made for the following package capacities of Mixed Fertilizers:

38.48%	for the packaging of 50 lbs. per sack
40.83%	for the packaging of 80 lbs. per sack
20.69%	for the packaging of 100 lbs. per sack
100.00%	

We made a study last year to determine the number of different sack widths that the fertilizer industry used for the packaging and shipment of mixed fertilizers. This study revealed that 96.66% of the total volume of sacks demanded by the fertilizer industry for the packaging of mixed fertilizers was made from 12 shipping sack paper widths, while only 3.34% of the total volume of sacks demanded was made from as many as 18 odd widths of shipping sack paper.

The point I wish to emphasize is that the packer may have a very practical need to specify sacks that are within this category of odd widths. But then again, we may not have a practical need to specify sacks made of these odd widths. We believe he should consult his sack supplier and request him to make a study of the different sack widths he is using, to determine if there could be some degree of standardization of his sack widths which could possibly give his company the benefit of worth-while economies and also assure better service from his sack supplier.

Our industry continues research into many new fields and we are constantly vigilant to the changing requirements of established territories to determine where and how we can achieve even higher degrees of Multiwall Protection and introduce new automatic packing, weighing and closing devices and materials handling methods which will save time and money for our customers.

Today, the Paper Shipping Sack Manufacturers' Association is proud to present to you, three gentlemen, each one an expert in his field, who have volunteered to come to this meeting to help in every way they can to promote a better understanding between your industry and ours—to learn your problems — to answer your questions — to get together with you for an informal talk about mutual problems.

Mr. John H. Dively will cover the subject of Materials Handling—Palletizing and stowing of cars and trucks.

Mr. Robert J. McDonald, on the subject of Packing and Closing Machines.

Mr. William L. Shoemaker, on the subject of Sack Constructions—Types and Uses.

First we will ask Mr. Shoemaker for a brief outline of his subject, next Mr. McDonald and then Mr. Dively.

Immediately after these three presentations, we would like to have questions from the floor. Will anyone who has a question, please raise his hand and state his question. I will repeat the question so that everyone understands it. Then either Mr. Shoemaker, Mr. McDonald or Mr. Dively will answer.

In case there are questions which members of this panel may not be able to answer readily, it would be sincerely appreciated if anyone in the audience who may have a proper answer to the question, will raise his hand and we will give him the floor. In this way all of us will enter into the discussion this morning and gain immeasurably from all of the experience and know-how assembled in this room.

If time runs out on us, I would welcome any of you to write your question on these stamped and addressed post cards which I have here. Drop them in the post box and we will certainly try to get answers back to you at our earliest possible opportunity.

We consider your questions to be significant of your packaging problems and therefore we welcome them so that we may know your problems and be able to better serve your industry.

Conclusion

Gentlemen, in behalf of the Paper Shipping Sack Manufacturers' Association, we thank you for inviting us to join you on this occasion to exchange our thoughts for yours on problems of mutual interest.

We give you our assurance that our industry is most desirous to cooperate with you to the fullest extent in your best interests.

We shall continue to strive to earn your confidence through the quality of our products and our service to your industry.

The first gentleman that I would like to call on is Mr. Bill Shoemaker, who will cover the subject of bags and barrier walls and types of bags.

William L. Shoemaker

Sack Constructions

I am not a chemist. I know very little about farm chemicals and therefore I will not attempt to get into any discussion on farm chemicals with you experts. Apparently the main reason I am here today is that I have had a little experience with multiwall paper shipping sacks.

The design of a multiwall paper shipping sack is not an exact science. If it were, a number of us technical boys would be out of a job. There are no hard and fast rules listed in a text book or handbook for determining the best bag design for a particular product. A particular bag design, meaning—type, construction . . . including special papers, valve types and closing materials, etc.—may appear to be the perfect bag for the John Doe Fertilizer Company, but for one reason or another, it does not seem to perform in a satisfactory manner for the X.Y.Z. Company.

For instance, I have seen cases where fertilizer plants of two different companies, located side by side on a highway, using two different type bags, and in some cases—different constructions, and each company was convinced it was using the best bag; and the funny thing about it—it may be they were! Even though they might, at least outwardly, be producing identical products, there undoubtedly are differences—perhaps minor—in their production methods, or in their packing and materials handling operation or in their marketing operation, or perhaps somewhere else. Their sales department may have decided on a particular bag type or design for esthetic reasons—for instance, without full consideration perhaps of all factors that should be taken into consideration when designing a multiwall paper shipping sack.

There are three basic bag styles or types being used today to pack fertilizer; that is, the sewn open mouth, the sewn valve, and the pasted valve type bag. Of the pasted valve type, there are two different designs: that is, the conventional flush cut type and the pasted valve stepped-end type... an offspring of the conventional pasted valve bag which is very popular. Generally speaking, local plant production methods, handling and/or shipping conditions as well as bag constructions . . . and the latter can be most important . . . may or may not dictate the one type which may outperform the other three types. If I consider the stepped-end type as a fourth type for the moment.

A look at the record of the past six years might be interesting to you. In 1955, members of the Paper Shipping Sack Manufacturers' Association produced a total of nearly 194 million Sewn Valve fertilizer paper shipping sacks. This total includes all bag sizes: 25s, 50s, 80s and 100# bags. In 1960, this figure dropped to a total of 72 million Sewn Valve bags of all different sizes . . . a drop of over 62%.

In 1955, nearly 193 million Sewn Open Mouth bags were produced by members of the Association for the fertilizer industry... again the total includes ALL bag sizes and capacities, but by 1960 the total for Sewn Open Mouth type paper shipping sacks had grown to 246 million bags . . . an increase of 53 million bags or over 27%.

The next are interesting figures to note: In 1955, the total for Pasted Valve paper shipping sacks produced by members of the Association, of all sizes, was only a little over 3½ million fertilizer bags, but in 1960 this figure had risen to nearly 65½ million bags... an increase of over 1700%—and is still clibming. In other words, the growth in total numbers of Pasted Valve bags and Sewn Open Mouth bags almost made up for the losses incurred in the numbers of units of Sewn Valve bags. Now, as you can see, I am only referring . . . in all cases . . . to numbers of units of paper shipping sacks produced. It is well to bear in mind when considering these numbers, that in the past few years there has been a trend toward the smaller capacity bags, away from the 100# size. For instance, the 25# and 50# bags are now quite popular.

Among other possible reasons, there are at least three basic reasons, in my opinion, to explain the dramatically increased use of Pasted Valve bags.

In 1955, asphalt laminated paper was practically the only type of paper used as a moisture barrier ply, in fertilizer bags. Also in 1955, the stepped-end Pasted Valve type bag had not yet come on the market or at least it was not yet a factor. As you know, the conventional Pasted Valve type bag is one where all of the plies have been cut off flush at each end of the tube, with each ply tightly cross-pasted to each other at the ends before the valve and butt flaps are formed and pasted. The bottom and valve ends are folded into what is called a satchel bottom fold, and the flaps pasted together—leaving an opening at one of the top end corners for a valve through which the bag is filled.

Generally speaking, asphalt laminated paper was not frequently used as a ply in the conventional Pasted Valve bag, since . . . while actually it seldom happened . . . it was possible that the laminated sheet, under certain conditions: for instance, extremely cold weather, might cleave or separate and valve or butt end failure might result. Poly coated paper at that time was never used in a conventional Pasted Valve type bag, as the means for positive glueing the ends of a pasted bag containing a poly coated ply, had not yet been developed.

With the advent of the virtually siftproof *Pasted Valve Stepped-end* bag, about 1956, special papers such as asphalt laminated and poly coated could be safely utilized in the construction of a *pasted end* bag. This was due to the manner in which each ply at each end of the open tube was stepped or shingled, thereby permitting each ply to adhere directly to itself when the valve and butt end flaps are folded over. If for some reason an asphalt laminated ply cleaved or separated, or the glue on a poly coated ply let go at the bag ends, the bag would not necessarily be ruined, since the other plies would probably hold. Furthermore, in the past three years, the means have been developed . . . through special treatment processes to poly coatings . . . to permit use of polyethylene-coated paper, even in the conventional Pasted Valve bag; that is, it is now possible to glue polyethylene with regular adhesives on a multiwall sack bottoming machine and maintain a normal rate of production.

By themselves, these two reasons: 1. The advent of the Stepped-end bag, and — 2. The ability to use safely, either asphalt laminated or polyethylene coated paper in a Pasted type bag, for moisture protection . . . probably would not have been enough reason for the Fertilizer Industry to swing a large portion of its bag requirements from the Sewn Valve type to the Pasted Valve type, meaning — primarily — to the Stepped-end type. A third reason became important: —Appearance.

In the first place, to some people at least, the Pasted Valve bags, whether conventional type or Stepped-end, looks better when filled or stacked on a pallet or skid. Brand name printing on the butts and valve ends, shows up better in a stack. Also, the Pasted Valve types seemed to stack and handle a little better on pallets. Furthermore, if the more siftproof Stepped-end type bag is used, the outside of the filled bag is usually a little cleaner. If a bag looked better, it was thought it also would sell better, and maybe it did . . . and is! At any rate — whatever the reasons, real or imagined — the Pasted Valve type bag, Stepped-end or conventional, is a very definite factor in the packaging of fertilizer today.

So much for our little discussion on bag types.

The use of moisture barrier plies in multiwall bags has steadily increased in the past few years. It is interesting to note that the original moisture barrier ply developed for use in multiwall bags, was developed expressly at that time (around 1932) for use in fertilizer bags. This was asphalt laminated kraft paper. For fertilizer, asphalt laminated is still the most widely used moisture vaporproof paper used as a ply today. The most common construction used has been what we refer to as a 30/30/30 AL, meaning . . . two 30# plies of asphalting kraft paper laminated together with 30# of asphalt.

Asphalt laminated paper as used in multiwall bags, is very special. It has to be flexible and remain strong at low temperatures, must not bleed under a reasonably high product packaging temperature, and must possess good moisture vapor protective properties. and others, have been built into asphalt laminated paper over the years.

Over the years, Sewn Open Mouth and Sewn Valve type bags, made with at least one ply of asphalt laminated paper as a moisture barrier, were used to package everything from ammonium nitrate to low-analysis fertilizer such as 5-10-5, but in time it became obvious that the more critical and expensive ammonium nitrate required more protection than 5-10-5. Thanks to research and development, multiwall bags containing a polyethylene coated ply have been developed by the Multiwall Bag Industry to take the place of *some* asphalt laminated paper in bags for packaging the more critical and expensive agricultural chemicals.

Polyethylene coated paper first came into use in significant quantities in multiwall bags about 1950. Depending on coating weight, polyethylene coated paper is a better moisture barrier than asphalt laminated paper. Also, it has other properties which are quite desirable, such as grease resistance and resistance to acid or alkaline attack. As a rule, however, polyethylene coated paper, even in the light weight coatings, has in the past been more expensive than asphalt laminated.

In 1950, Members of the Paper Shipping Sack Manufacturers' Association cut up 2,052 tons of poly coated paper, while producing 2 Billion 91 Million multiwall shipping sacks of all types for all kinds of commodities. In 1960 this figure had grown to 20,918 tons of poly coated paper, and Members of the Association produced more than 2.4 billion bags. During this same period the use of asphalt laminated showed an increase in use and then a fall-off. In 1950, 71,883 tons of AL were used in multiwall bags. This figure increased to 89,081 tons in 1951 and then fluctuated up and down somewhat, but by 1960 the total asphalt laminated tonnage had dropped to 66,687 tons . . . which is still a very substantial figure.

The asphalt laminated paper and the poly coated paper tonnage just referred to, was used in shipping sacks for all kinds of products, not necessarily fertilizer. In fact, very little of the poly coated paper was or still is used in fertilizer bags.

The use of poly coated paper in bags has steadily increased as production techniques have improved and the price of the resin has decreased. It is now possible to obtain a light weight coating of polyethylene on kraft in a bag at approximately the same cost as a bag containing a 90# asphalt laminated ply. For low analysis fertilizer used *in* season after little or no storage period, in my opinion, there is little to choose from between the two type papers. For long-term storage, under humid conditions, the polyethylene coated paper naturally will provide fertilizer with better protection against caking.

As far as bag design is concerned, probably the most important new feature has been the recent development of valve inserts or internal sleeves made from light weight free poly film. Such sleeves have been developed for use in both the Sewn Valve and Pasted Valve bag types. In other words, instead of using kraft paper as the stock for the internal sleeves, which, as you know, are designed to close off a valve opening after a bag is filled, poly film is being used. I might add that results to date indicate that the poly film sleeve shows an improvement over the paper sleeve for sealing off valve openings.

When poly coated paper was first introduced to the Multiwall Sack Industry, a more or less common polyethylene resin was used. Naturally, there were some differences in the resins produced by various resin-producing companies, but the important thing was that in the main, they were low density resins having a density of approximately 0.92 grams per cubic centimeter. Also, with the extrusion coating methods and machinery then available, the protective characteristics of coatings were fairly uniform regardless of who did the coating.

With more or less popular approval, four coating weights of poly to kraft came into use: 20#, 15#, 10# and 6#, all calculated on a 3000 square foot ream basis. Usually the poly was coated to a 50# sheet of kraft paper. The 20# coating of course afforded the greatest protection to the product; and the 6#, the least. Once a multiwall bag user determined which coating weight afforded his product the required protection, whether against moisture or grease pentration or chemical attack, it was a relatively simple matter for him to specify on his bag orders which coating weight of poly he desired, and any Multiwall Sack Manufacturer understood exactly what was required of him. In recent years, however, we have seen many changes and improvements to the resins produced and used, and technological improvements in extrusion coating methods and equipment. Actually, this has all been good news to the multiwall bag user since, usually, each improvement meant that a lighter coating weight of poly could be used, at a lower price to the user . . . and the user still obtained the product protection to which he had been accustomed. In some cases the user has obtained even more protection at less cost.

Unfortunately, considerable confusion among the bag users and bag manufacturers alike, has resulted from the introduction of various poly coatings made from different density resins, or due to other differences in the coating, and also each bag company has usually introduced its line of poly coated papers under its own trade name. We reached the point where an 8# coating of high density resin . . . meaning a resin density of approximately 0.96 grams per cubic centimeter . . . was touted by one bag manufacturer as being equivalent to a 15# coating of low density resin; which in turn was considered to be equivalent to 10# or 12# of medium density poly, by another company. And then some bag companies . . . usually those with their own poly extruding departments . . . and with improved equipment and advanced technical know-how, have been able to produce a better coating than before, with the result that even less coating weight of film might be used and still maintain the required protection. In other words, there have been improvements in the resin used, in the extrusion equipment and in the methods of extruding.

As stated before, all of this work has usually resulted in a lower priced package to the bag user but has created some problems in procuring the same amount of protection from two, three or more bag suppliers who, conceivably, might be using different coating weights of different density resins to compete with each other.

This is a problem now well recognized by the Technical Committee of the Paper Shipping Sack Manufacturers' Association and steps are being taken to simplify the specifications for poly coating. In other words, this is one of the jobs that has to be done in the near future by the Multiwall Bag Industry . . . and will be done. Most probably, the end result — whatever the final form — will be built around the specifying of moisture barriers, whether poly coated or poly film or asphalt laminated — or some other barrier now in use or yet to be developed, will be in terms of MVT performance, which means by moisture vapor transmission rates rather than by coating weights. Then, if such proves to be the case, all a bag user would have to determine is the M.V.T. rating in grams of moisture required to protect his product, and he then could specify this figure on a bag order and at least, theoretically, not care what barrier paper is used in his bags as long as the barrier paper meets his test requirements, and is competitive in price.

In closing, I would like to emphasize that a system for specifying moisture protection by M.V.T. instead of by coating or trade name . . . while in partial or taken use by some bag companies at this time . . . is not an accomplished fact industry-wide. Many problems of a technical nature have to be overcome first, not the least of which is the adoption of uniform procedures for sampling and testing the barrier paper contained in a carload of bags . . . in case there is a controversy. Definite, uniform procedures have to be established for evaluating moisture barrier papers; procedures that can be easily followed and adhered to by bag user and bag manufacturer alike.

MR. POCTA: Thank you, Mr. Shoemaker.

Now, gentlemen, we will have Mr. Robert MacDonald cover a subject which is bag packing machines and closure equipment.

Robert J. McDonald

Packers — Review

It seems natural enough that we should look next together at bag packing equipment. We might say that now you know more about bags, we should be sure that you know as much as possible how to use them. There is really not quite so much new in equipment itself as there is in the manufacture of bags, but there are steady advances in the techniques of its use. Our industry recognizes its responsibility to refine these techniques, as well as improve the equipment as much as we are able.

To take a first look together today at what equipment you have and what you may expect, our review as we have chosen to call it might best be focused briefly on certain features of the several kinds of packing equipment you know about that are common to the most successful devices doing your job for you. Whether you use valve bags or open-mouth types, there are certain fundamentals encountered in packaging such particular chemical products, especially, that are distinctly important to you and therefore to us.

Perhaps the most important requirement of packing equipment that concerns you is that it must fill your bags accurately — that is, with respect to weight as well as volume for the ultimate confirmation of a bag is also vital to your success in the market place. You have had a discussion about weighing scales in your meeting already so we would ask you to let it suffice for us to say that as manufacturers of packaging equipment we give particular attention to the principles involved. Actually, our concern goes all the way back to the supply feeder elements, into the immediate bins, and is emphasized in the design of belt feeders which you have learned to recognize as best for your conditions. We must concentrate on close coupling of components in the equipment which transfer your product from one stage to another — minimum product in suspension is essential to the success of dynamic weighing such as must be employed to give you the production rates and capacity your business demands. We have developed pneumatic control elements for positive application of maximum power to cut the flow of your product; we have adapted wide varieties of electronic controls for these power devices in the interests of instantaneous sensing and immediate reaction. We have learned that your equipment must be made of materials that resist corrosion — stainless steel is common-place, and have no doubt that we are looking ahead to the use of plastics. We have studied how to build your equipment ruggedly, for hard use generally and to stand up under the extra loads of peak demands — as when your yard is full of trucks waiting to be loaded while your cash register is waiting to be rung. With all this we give careful attention to simplicity, to insure maximum speed in this necessary function of packaging with a minimum of effort in operation and maintenance alike.

We recognize that our responsibility to you clearly extends into such areas as labor-saving, surely—and this is where cooperation, as demonstrated so notably by the fact of our meeting here together like this, is especially important and beneficial to both of us. By making it possible for you to make the most effective use of your labor and facilities in your use of bags, we really help ourselves by making the use of bags more attractive to you. In other words, we welcome opportunities to work with you and for you because this is good for us.

You can be sure that we are giving close attention to new developments in materials, such as you have heard about here today, and looking out sharply for their effect in bags, on the kind of equipment that will serve you best in their use. This is where we give particular attention to labor-saving in the development of such devices as bag holders, insuring time-savings and complete accuracy in weights and closures alike; to automatic aids to expedite and mechanize the simple functions — as motor actuators and thread clippers to operate sewing machines without the help of hands; to the ultimate design of bag closing conveyors that clean themselves of corrosive build-up and carry bags through the sewing machine even better than human hands and without this constant attention of your manpower. Even now and surely just ahead are automatic bag placers and closers to permit the general use of multiwall bags by putting them on the bag holders by machines instead of hands and making a perfect sewed closure with no manpower at all. These maximum devices may not be needed for every single plant application today, perhaps, but certainly it is time for them wherever there is regular clock-like, uninterrupted packaging production — and this is the condition in your industry, as you know, more and more.

The advances we have made together can be clearly seen. Where three men were once commonly employed at bag packing stations the maximum is now rarely more than two; one man plus is actually very practical with modern equipment today, and just part-time of only one man is now entirely realistic to think about. Working along these lines, and in this direction to help you, selfishly or not, we welcome the obligation to make it possible for you to make better use of the better bags we'd better make for you."

MR. POCTA: Thank you, Mr. MacDonald.

Now, gentlemen, Mr. John Dively will present his subject on materials handling.

John H. Dively

Materials Handling — Bags Palletizing and Stowing

With the trend toward smaller packages, more grades, and increased pressures from your sales departments for better service for your customers, many of you are taking a serious look at palletized warehousing systems as a possible solution to your filled bag handling problems.

In the main, you are looking for a system that will reduce your costs while it improves your service and yet it must be economically feasible and fit into the limitations of your present plants. This is a big order to fill, and I am sure all of you realize that the bag handling problems of your industry are too complex to be discussed fully during a twenty minute presentation, and therefore I shall not attempt to do so. Instead, I believe more can be accomplished if I review briefly the systems most commonly used today in order to pinpoint their strength and weaknesses and then discuss at length a new warehousing system that some of you are considering.

The first system I'd like to touch on is hand trucking. Although hand trucks have been in use for many years and may be considered obsolete by some of you, they are still used to good advantage by many plants.

Hand trucks were unbeatable in the days of large bags, heavy rail shipments, and cheap labor. The one big benefit they provide is *flexibility* and because of it many hand trucks are still in use today.

Here then we have one of the fundamental requirements that you must look for when you are evaluating a new filled bag handling system. Make certain that it provides *flexibility*.

Hand trucking began losing favor after World War II as a result of the trends toward smaller bag, truck shipments, additional analyses, and higher labor rates. These changes caused a substantial drop in daily tonnage from the mills and also reduced tons per man hour. Long runs on each grade were no longer possible, and more labor was required to handle the smaller bags and to cope with the problems of truck loading. As a result, cost per ton increased.

In certain areas, notably the Northeast and Midwest, many plants installed conveyors to transfer the filled bags from the mills directly to the trucks. Most of these conveying systems provided two-point loading by including a reversible conveyor in the system to deliver the filled bags to either of two truck loading belts. The primary purpose of this system was to reduce labor.

In actual operation, this system did reduce labor; but, at the same time, it also reduced daily tonnage at most plants. This drop in tonnage was due primarily to the fact that the two-point loading system is in reality a *closed system* and therefore is very inflexible. For example, with it each grade must be packed to the exact amount and in a sequence that corresponds to the loading patern desired by the customer. This causes frequent grade changes at the mill. Delays also occur if more bags are filled than required or if less bags are filled than required. In fact, delays in any part of the shipping mill — feeding of the elevator, malfunction of bagging equipment, or broken bags — adversely affect production.

On mills using a closed conveying system, it is not uncommon for the accumulated idle time that is caused by grade changes and miscellaneous shutdowns to reduce tonnage per shift by ⅓ or ½. This means that a shipping mill which is normally operated at twenty, eighty-pound bags per minute, will generally average only 200 to 240 tons per shift, instead of approaching the maximum 340 to 380 tons. I do not mean to say that *all* of this loss in tonnage is due to the conveyors. However, the basic design of the system does contribute substantially to low daily tonnage.

This brings out two (2) important points to look for in a new system in addition to flexibility. Make certain that the system is capable of *providing adequate tonnage per shift* with *minimum labor cost per ton.*

Many companies have modified their truck loading conveyor system by adding a small service warehouse in an area adjacent to the loading dock. This change provided some flexibility to the system and helped to improve daily tonnage for many of the plants that are still using truck loading conveyors.

The purpose of this quick review, which I readily admit was over-simplified in the interest of conserving time, was to establish the basic requirements of a good materials handling system for bagged goods.

In my opinion those requirements are:

1. The capabilities for moving high tonnage.
2. Low handling costs per ton of bagged goods moved.
3. Flexibility to assure that customer service will be fast and efficient.

Now let's take a look at a warehousing system that may be new to some of you. I want to point out right at the start that I am not speaking about the small, poorly located storage areas called warehouses which can be found in most plants today.

Instead, I am talking about the modern warehouse which has *ample storage,* one that is properly located for *easy accessibility* and one that *divorces packing and shipping.* The packing gang moves all bagged goods into this type of warehouse on pallets. The shipping gang fills all customer orders from warehouse stock. For practical purposes, this system completely eliminates direct loading of trucks from the mill.

What are some of the features of this system:

1. It provides flexibility.

   Fork trucks, like handtrucks, have great freedom of movement.

2. It divorces packing from shipping.

   This makes possible long runs on the packaging equipment. Generally, three to eight grade changes per shift are ample. At the height of the season it is not unusual to pack the number one grade (biggest mover) throughout the entire morning. These long runs provide an increase of 30% to 50% in tonnage packed per shift from the average shipping mill.

3. It makes possible improved customer service.

   By filling customer orders from warehouse inventory, trucks can be loaded rapidly, regardless of the number of grades per load. In addition, several trucks can be loaded simultaneously. Also since more tons can be packed per hour at the mill, there will be more tons of bagged goods available to ship.

4. It provides maximum tons per man hour.

   Many factors contribute to productivity per man hour. With the warehousing system, the major contributions are: Reduced idle time, long runs on the packing equipment, transfer of filled bags on pallets in lots of one to two tons, separation of packing and shipping, and filling of customer orders from warehouse stock.

The combination of these features makes possible better service and lower costs provided the system has been planned properly and is operated correctly. In other words, a warehousing operation, like any other segment of your production facilities, must be well engineered and well managed in order to produce the desired results.

The following are two of the most important factors to be considered during the planning stage of a warehousing system:

1. Choice of warehouse locations:
   - —It must be easily accessible to trucks.
   - —It must provide ample yard area for truck maneuverability.
   - —It must be large enough to provide ample storage and loading areas.
   - —It should be close to the shipping mill.
   - —It should be near the railroad siding.
2. Planning the warehouse layout:
   - —It must have ample capacity.

—Ample wall space is a very important consideration, therefore, a rectangular shape is generally best.
—All aisle ways should be at least 12′-0″ wide.
—The minimum width if storage is along one wall only should be 30 to 35 ft.; for storage along opposite walls, width should be 55 to 60 ft.
—Length is determined by the capacity required after allowing for 12′-0″ aisle ways, empty pallet storage, palletizing area and loading dock.
—Overhead clearance should be 15′-0″, if possible.
—Concrete floors should be used.

The production requirements and special needs of each plant influence many other important factors. These variables must also be taken into account during the early planning stages:

1. Tonnage—daily, seasonal annual.
2. Packing rates.
3. Number of grades packed.
4. Net weights and bag sizes.
5. Number of shipping mills and capacity of each.
6. Design of palletizing station.
7. Shape and size of pallets.
8. Fork truck specifications.
9. Inventory of bagged goods in the warehouse.
10. Primary objective of the new system — is it to improve customer service, increase tonnage, reduce costs, or to provide daylight packing and loading.

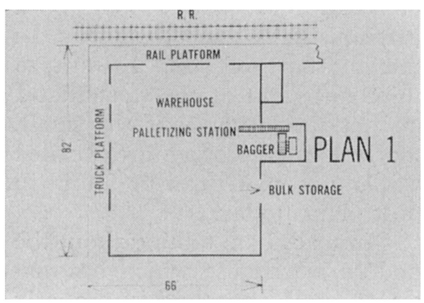
As you can see, an efficient warehousing system will not become a reality just by accident — it must be pre-planned. At the height of the shipping season a modern fertilizer warehousing operation is alive with activity, in fact, it is alive with many activities all happening at once — fork trucks traveling back and forth, men palletizing filled bags, loaded pallets going into storage, loaded pallets coming out of storage, customer's trucks being loaded, and in the yard highway trucks turning, backing, coming and going.

All of these activities must be taken into account during the early planning stages if you are to be assured that the end result will be a smooth, efficient, productive adjunct to existing plant facilities.

That this type of warehousing operation for filled bags is a practical system for fertilizer has been proven by members of your industry. Those who are using it today *are* enjoying the following benefits:

1. Improved customer service.
2. Increased tonnage from existing mills and, in certain instances, the complete elimination of one or more mills.
3. A much higher percentage of all packing and loading being done during the day shift.
4. Increased earnings.

Now, I'd like to show you the layout of two fertilizer warehousing systems and a few colored slides that were taken of the operation of each of them.



Slide 1

Slide #1 shows the floor plan of a warehouse at Central Chemical Corp., Hagerstown, Maryland.

Ideally located with regard to the truck loading platform, railroad siding and the bagging station—the latter is adjacent to it.

The palletizing station is near the one wall and just off the center aisle way. This provides minimum travel distance for the fork trucks taking loaded pallets into storage or from storage to the loading.

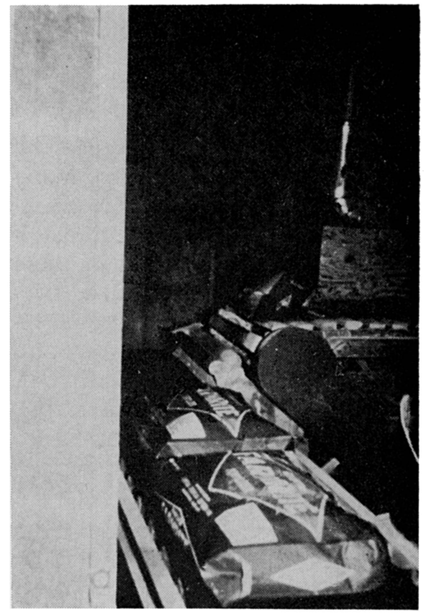
There is ample yard for trucks to turn around and back up to the shipping platform.

It has good wall space and a capacity of 400 tons.

It provides excellent accessibility to the loading platforms.

Slide #2 shows a view of the 18″ conveyor that transfers the filled bags from the packer conveyor to the palletizing station.

This conveyor delivers the bags



Slide 2

lengthwise rather than crosswise —lengthwise delivery is very important for easy high speed palletizing.

This conveyor is approximately 36″ above the floor.

Slide 3

Slide #3 shows the palletizing station.

It shows 80# bags, size 18½ x 25¾″ face length.

Pallet size is 42″ x 42″. A 4 — bag, 6 high, pin wheel or chimney style stacking pattern is used — plus one bag down the hole in the center thus providing one ton per pallet. The filled bags should overhang the pallet by 1″ to protect the bags from damage.

Notice the load is well interlocked, making possible rapid handling by the fork truck without danger of bags sliding off the load. The load is square and flat. This is very important for tiering 3 or 4 high in the warehouse.

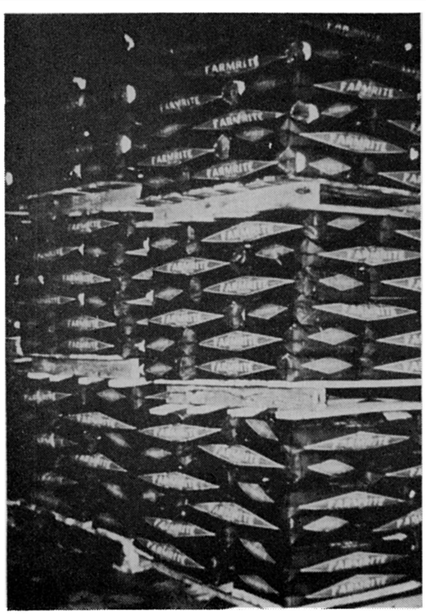
Some plants use a long, narrow pallet which is roughly twice the width and twice the length of

the filled bags to be palletized. On these pallets, "column stacking" is used—four columns per pallet—without interlocking the load. This is an easy pattern to stack on the pallets and to unload by the truck loading crew, but the loaded pallets must be handled carefully by the fork truck operator to prevent the column from tumbling over when turning or stopping.
Pallet size and palletizing pattern are two variables that must be analyzed carefully during the planning stage of a warehousing operation.

Slide 4

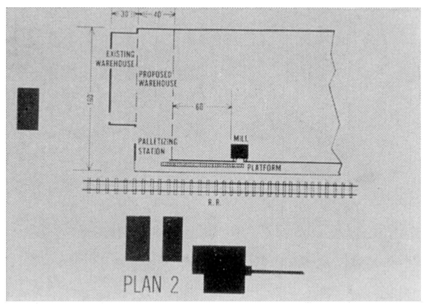
Slide #4 shows the fork truck transferring a load pallet to the truck loading platform.
A one-ton capacity fork truck is used by this plant. It has excellent maneuverability and can be driven onto many of the customers' trucks.
It is somewhat less stable than a two-ton fork truck for stowing pallets 3 and 4 high in the warehouse.

Slide 5



Fork truck specifications must also be decided upon during the early planning stages of a warehouse operation.

Slide #5 shows the pallets in the warehouse.
In this plant the pallets are stacked 3 high. Each column is approximately 10 feet high.
Some companies stack them 4 high. This is another variable to be considered early in the plans.
Notice the straight stacks and level pallets — This is important for safety reasons and for easy pick up of loaded pallets going to customers' trucks or railroad cars.

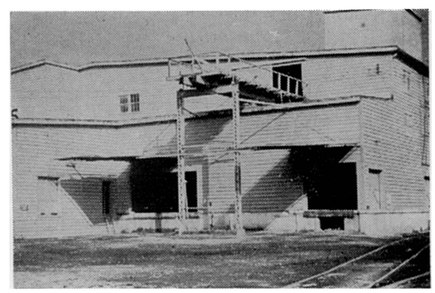


Slide 6

Slide #6 shows a portion of the plant layout at F. S. Royster Guano Co., Indianapolis, Indiana.
This shows what compromises can be made, in fact, at times *must be made*, in order to add a modern warehouse to an existing plant.
They had a small warehouse at the end of the plant. It is marked "existing warehouse" on this print. It was rather inaccessible to the shipping mill and therefore it was used very little except for service items such as ammonium nitrate, urea, etc.
There was space in the yard at either of two points to build an adequate warehouse but this would have left insufficient space for trucks to turn and back up to the shipping platform.
After considering all factors they finally decided to use two 20 ft. wide bulk storage bays at the end of the factory for the new warehouse. On the sketch, this area is marked "proposed warehouse."
That area plus the "existing warehouse" gave them an excellent warehouse for palletizing storage.

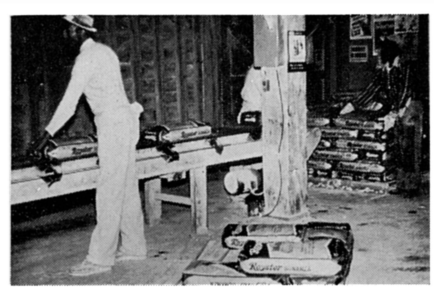
- —Ample capacity (1400) tons).
- —Excellent shape with lots of wall space.
- —Ample space in the yard for trucks.
- —Access to the railroad siding.

The new warehouse was not adjacent to the shipping mill but this was solved by installing an 18" wide conveyor to convey the filled bags from the mill to the palletizing station.
The palletizing station is at one end of the warehouse and resulted in long trips for the fork truck for the bagged goods that was stored at the far end of the warehouse. This potential problem was taken into account during the early planning stages because it influenced many phases of the operation — arrangement of inventory, pallet size, pallet load, fork truck specifications, and location of truck loading doors.



Slide 7

Slide #7 shows a view of the end of the factory where the warehouse is located.
Notice the railroad siding, truck loading doors, and the area in the yard for trucks.



Slide 8

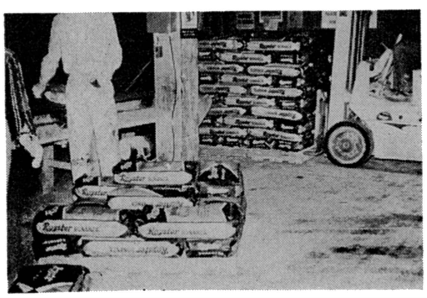
Slide #8 shows the palletizing station.

The bag conveyor is 18″ wide and 36″ above the floor. It delivers the bags in a lengthwise position.

50# bags, size 16 x 24¼″ face length, are palletized at rates of 28 to 34 per minute.

Three men are used—two work as a team and the third as a relief man. He also spots the empty pallets.

Pallet size 48″ x 48″ and an 8-bag interlocked stacking pattern, 10 high, that provides two-tons per pallet, was chosen after very careful analysis. One disadvantage is the complexity of the pattern, but the combination provides several benefits — a stable load that can be transferred rapidly, stored 3-high easily, and one fork truck can take care of the palletizing station since approximately 2½ minutes are required to load each pallet.



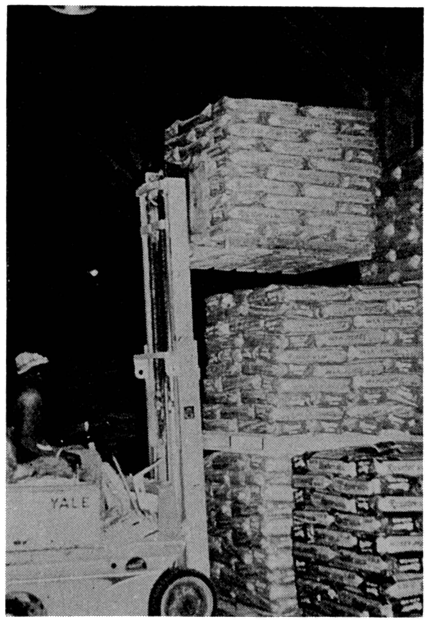
Slide 9

This is another shot of the palletizing station. Slide #9.

It shows the fork truck picking up a loaded pallet. As you can see, the palletizing crew has simply moved to the other pallet loading spots which are located along the one side of the conveyor. As soon as the loaded pallet is removed, the relief man will "spot" an empty pallet at the end of the conveyor.

Slide 10

Slide #10 is a "close-up" shot of the two-ton fork truck taking the loaded pallet to storage. Notice the square, level, interlocked load—it's beautiful. In fact, they do an outstanding job of loading pallets — this is evidence of good supervision.



Slide 11

Slide #1 shows the fork truck tiering loaded pallets, 3-high in the warehouse.

Since each loaded pallet is approximately 4½ feet high, the top of these columns are approximately 13½ feet above the floor.

48″ x 48″ pallets permit columns of this height to be tiered easily and rapidly provided, the individual pallet loads are flat and square. They are also safe when done properly.

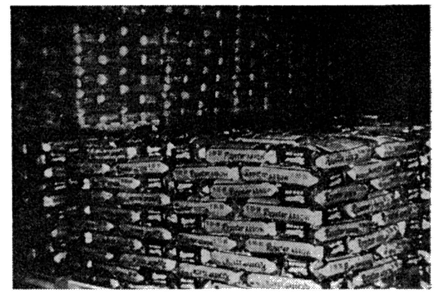
Notice the rugged appearance of the two-ton fork truck and large pallet—they give you a feeling of security.

By using two-ton pallets, tiered three high and six deep from the wall, each column provides 36 tons of storage.

Slide #12 is another shot in the warehouse.

The foreground shows loaded pallets stored one high only as they normally store goods during slow periods. The background shows three high tiering. During busy seasons, all goods are tiered three high.

The combined weight of a two-



Slide 12

ton fork truck and a two-ton pallet makes it mandatory that a truck dolly be used to handle the loaded pallet on most customers' trucks. Unfortunately, no trucks were loaded the day these slides were taken and so I cannot show the truck dolly in use.

To review briefly:

Location and size are probably the two most important factors to take into account in planning a palletized warehousing operation—once built the warehouse cannot be moved and alterations are expensive, if possible at all.

So called secondary factors must also be given proper consideration—items like packing rates, bag size, pallet size, fork truck specifications, arrangement of the warehouse stock, and tonnage requirements.

However, the benefits of a well planned and properly managed warehouse can be very rewarding in increased tonnage, better customer service and improved earnings.

Moderator Spillman: Thank you, Mr. Pocta, to you and your associates for an excellent and informative report on paper sack construction, packaging and materials handling.

We are going to have a few minutes for questions. We are running a little short on time. I would like to ask the first question, Mr. Pocta.

Many years ago, when we first started packaging in paper bags the basic weight for ream of paper as I understand it, 500 sheets, whether you use the 40 pound basic weight or 50 pound basic weight or whatever it was, was changed during World War II, from 500 sheets per ream to 480 sheets, which gave us a reduction in basic weight of 4 per cent. As far as I know, that weight hasn't been changed back and we're still figuring on 480 sheets as basic weight, aren't we?

MR. POCTA: 24 by 36, it's 500 sheets.

MODERATOR SPILLMAN: It's back to 500 sheets. In other words, the basic weight is back as it was prior to World War II.

That clarifies that.

It looks to me like the paper boys are in the same mess that we are in our mixed fertilizer business with grades upon grades being added and the oldtimers are not taken off. From what I gather from your conversation, you just have too many different types of bags doing the same type of job.

MR. POCTA: Mr. Spillman, as I stated this morning, we made a study of all of the different widths of bags that the fertilizer industry demanded of our industry, and 96.66 per cent of the volume involves the bag industry with having in stock constantly 12 different roller widths of paper, of different kinds also. Of the 18 odd widths which were demanded by the fertilizer industry represented something like only 3.44 per cent or 3.34 per cent of the total volume. My thinking is that we, in our industry, think that the mixed fertilizer industry should consult the bag suppliers, ask them if they couldn't make a study of all these odd widths which they use to see if they have a practical reason for using those odd widths. If they do, that's one thing, but if they don't, and can concentrate on fewer widths of bags, it would mean much greater economy in bag purchases, as well as better service from the bag industry.

I think there should be an effort made to do that by everyone, not only our industry, but yours as well.

MODERATOR SPILLMAN: We appreciate your problems and I think we can work those things out, but we get confused. We have different people coming to see us and each bag representative recommends a different type bag, for some reason or another.

MR. POCTA: Yes, but basically its the same old problem as to whether or not those odd widths are necessary to the efficiency of an operation. They may not be, and if they are not necessary, then it's to the fertilizer manufacturer's advantage to concentrate on fewer odd widths. Where he has to have them, of course, he has to have them, but we think that in some places they do not really have to have those odd width bags.

MODERATOR SPILLMAN: I have one more question and then we'll put the questions to the membership.

Again, many years ago, we did a lot of research on bag specifications. I go back to 1932. At that time we found that in order to get a bag to give us the least amount of breakage and to hold up in perfect condition from the plant to the customer, the bag specifications at that time were three 40 pound sheets and a 50 pound sheet, or 170 pound basic weight.

My question is, I know there are a good many bags made today with much less paper basic weight, and are the bag companies satisfied that the recommendations made today are a little on the low side or a little on the high side, or in between? Do we have the right bag for the job that we're trying to do?

MR. POCTA: I think, Mr. Spillman, that's a question for Mr. Shoemaker.

MR. SHOEMAKER: I think that the construction definitely is on the low margin side, Mr. Spillman; they're close to your very critical basic weight, but this is something, as I pointed out in my talk, that varies from plant to plant, under different handling conditions, shipping conditions, which, of course, affect the total basic weight, but I definitely think that on the average most people use a marginal in basic weight.

MODERATOR SPILLMAN: I have one more recommendation to make which may be significant.

We package at Baltimore 80 pound paper bags and for some time—and we still use a four wall paper bag, this is a valve bag, the construction is one 90 pound, two 40s and a 50, and believe me, boys, our breakage is down to a minimum. We have very little breakage, practically no breakage, and I think we can afford to pay more for our bags and the end result will be a saving in our packaging system.

Are there any other questions here? We're running out of time; we would like to have a few questions.

MR. J. M. BROMLEY (Canadian Industries Ltd.): I would like to hear some of the viewpoints of the people who are using polyethylene bags. There are a number of American people, and our concern in Canada is basic in this matter. We make polyethylene resins for these bags and we are having big success with them. I would like to hear some of the viewpoints of the people in the U.S.A. here using polyethylene bags.

MODERATOR SPILLMAN: Anyone here using polyethylene bags who would like to make some comments on their experience?

MR. SAM E. SHELBY (Federal Chemical Company): We do use polyethylene bags, to answer your specific question.

MODERATOR SPILLMAN: Have you had good or bad experience with these?

MR. SHELBY: I beg your pardon?

MODERATOR SPILLMAN: Has your experience in using polyethylene bags been good or bad?

MR. SHELBY: I would say it's been very good. When we use a completely polyethylene bag.

MODERATOR SPILLMAN: Mr. Shelby, what is the construction of that bag? Your wall construction and the weight?

MR. SHELBY: It is a single sheet, clear polyethylene, 5 mills in weight.

MODERATOR SPILLMAN. Yes.

MR. SHELBY: The polyethylene bag does not give you any problem on excessive paper slipping. The area of contact of the paper bag is not as great as the area of contact of the polyethylene bag. The polyethylene bag does not slide off the truck any more than paper.

A VOICE: Have you solved the sealing problem?

MR. SHELBY: We have been very successful in sealing up to 26, 28 bags a minute.

MODERATOR SPILLMAN: We cannot hear the questions.

A VOICE: What is the shape of the bag?

MR. SHELBY: The bag is 26 inches in length, it varies in width from 16 to 17 inches.

A VOICE: What about breakage?

MR. SHELBY: The present experience has been that the breakage is not any greater than a 50 pound paper bag.

MODERATOR SPILLMAN: Thank you, Sam.

MR. SHELBY: I would like to ask a question of Mr. Dively, if I may. He was discussing the warehousing from the filler to the pallet. I would like a little more discussion from the pallet to the truck, considering the fact that all these trucks are not big trucks that we can drive onto with a fork lift, but they're farmer trucks with holes in the bed and so forth. (Laughter.)

How would you handle the loading of that type of truck?

MR. DIVELY: You mean a two-ton fork truck, a two-ton load on the pallet? To my knowledge, they do not drive onto any trucks. They may. If they do it, I imagine it would be very few. But they do use a truck dolly. They have that on the truck, the truck backs up to the loading dock and they set this truck dolly on the truck bed, right up at the back end by the tail gate and then the fork truck comes up to the back of the truck—not onto the truck, to the back of it, deposits the two-ton pallet on the dolly and then the men push it to the front and unload it. I think they pack approximately 25 different grades at Indianapolis, plus whatever happens with trace elements, etc.

MODERATOR SPILLMAN: We have time for one or two short questions. Any other questions?

Mr. Pocta, I have another question. Is there anything the bag manufacturers can do to alleviate the problem of paper bags drying out in our storage? I know you have given us a lot of specifications on how to help that problem but in a good many of our plants we just about have enough room to put the bags in the warehouse. We don't have the equipment to moisture these bags. Is there anything that can be done in the manufacturing process itself so that when a bag is delivered it will be as good the day it's delivered as all through the year?

MR. POCTA: Mr. Spillman, first of all, I would call attention to Section 1 in the Manual, and I put copies on the table there, for the purpose of humidity control.

I would like to turn this same question over to Mr. Shoemaker, because I think it's a double headed one.

MR. SHOEMAKER: It's a serious problem.

MODERATOR SPILLMAN: Certainly it is.

MR. SHOEMAKER: I doubt, with what I know about paper, I doubt if we could ever reach that Utopia, so to speak, of putting a bag in your warehouse storage and storing it and have the paper remain at the same level of moisture for quite a while.

In specific answer to your question, I think, yes, there could be an answer. It's possible, or feasible, we think, to add chemicals to paper that would help retain the moisture in the paper for a length of time, but this is expensive.

This has been looked into, I think, by all paper manufacturers over the years time and again, but it has been dropped, as far as I know, I know of the case in my own company, due to the cost involved. But I can't sit here and say that it wouldn't be resolved sometime. We do recognize that this is a problem.

MODERATOR SPILLMAN: It certainly is and sometimes I think you've got to spend a little money to make a little money.

MR. SHOEMAKER: It's not the question — it's easily added now to paper, something can be done to paper, but the question is of the market bearing the additional cost.

MODERATOR SPILLMAN: Are there any other questions?

MR. CHARLES A. LUBOW (Star Fertilizer Company): Mr. Chairman. I just wanted to make a comment regarding the reduction in the size of bags. I think we can all well remember when fertilizer was packed in 300 pound bags, and now it's 150, 125, 100, 80, and now we're talking about 50. It still takes one man to handle one bag, I don't care what size bag it is.

If we are definitely trying to reduce what small profit is left in the fertilizer industry, we can go to a 50 pound bag.

MR. POCTA: Mr. Spillman, could I just say one more very quick comment. We view our service, gentlemen, or our industry as being most desirous of cooperating with you to the fullest extent in your best interests, and we will continue to try to earn your confidence by the high quality of our products and the services we render.

Therefore, as I said before, these questions to us are very meaningful, and having in mind that possibly time would run out on us, there are cards, postcards stamped and addressed on that table and we would be very happy to have your questions and we'll answer them in good time.

Thank you very much for allowing us to be here today.

MODERATOR SPILLMAN: Thank you.

MODERATOR SPILLMAN: We have had many questions on how to control in-plant dust problems. There are a number of dust collection systems presently installed in fertilizer plants, the types of equipment are both the dry and the washer type. Our speakers, first, Mr. Harry E. Hoon, Jr. of Northern Blower Division of the Buell Engineering Company, will discuss generally the description of dust collecting equipment, and Mr. Gilbert G. Schneider of Western Precipitation Division of the Joy Manufacturing Company will give us a general description on the subject of dust control.

Mr. Hoon.

Materials Handling — In Plant Dust Collecting

Harry E. Hoon

Dust Collecting In Plant

I—*Why Dust Control* — In recent years, dust control equipment has been gaining wider and wider acceptance. The reasons are both economic and legal.

Some states and municipalities now have laws defining the use of dust collecting equipment in certain industries. On the economic side of the picture: the removal and control of dust helps prevent excessive wear on machine parts, motors and mechanical equipment. Heavy dust laden air impairs vision and therefore, in the interest of better work and safety conditions, dust removal is desirable. The health and/or comfort of the individual worker under present day labor negotiations is important as is the sentiment of the plant's neighbors or local community with respect to the dust that may issue from the plant. The last and probably most important factor is the potential recoverable value of the collected material. This takes the dust collector out of the necessary evil category and it becomes a piece of processing equipment.

II—*Dust Control*—What is involved in the control of industrial dust? There are two major problems. First, the separation of the dust entrained in the process air or gas steam and second, the collection of the dust at a point as close as possible to its source. Process industries such as fertilizer manufacturers require heavy duty dust collection equipment that will give continuous performance with a minimum amount of maintenance. Therefore, careful study and full understanding of the individual problem is necessary in order to arrive at a set of specifications for the selection of the dust collector and associated equipment. Consideration must be given to the advantages, disadvantages and limitations of all types of dust collecting equipment available and selection of the one most suitable for the particular problem. To do this, it is necessary to know the size, physical and chemical properties of the gas stream. Management naturally will want the most economical installation. The equipment selected in the layout should reflect this *only* if it will alleviate the conditions that make the initial expense necessary. Let's see how equipment is selected for existing plants and new plants.

Existing Plants — In existing plants where dust is generated by process handling, crushing, grinding, screening and packing operations, the dust should be collected at its point of origin. If, in each of these process steps, the proper confinement, enclosure, hooding and piping are utilized, then only a minimum volume of air will be necessary to insure proper carrying velocity of the dust collected. This is called "capture velocity" and it depends upon the creation of sufficient air flow, past the dust source, to carry the contaminated air from the source and into the exhaust hood. Another important consideration is the dust laden gas stream that is part of the process. Take drying for example. This is a critical problem in your particular industry for it effects your production and may make a complete mess out of any dust collection and the air handling equipment connected with it. The dryer basically has sufficient heat and retention time that the material passing through it will reach a temperature high enough to drive off the moisture contained in the product. The gas passes out of the dryer mixed with combustion gases and the excess air that passes through the dryer. In order to properly size and select dust collectors, it is necessary to determine proper gas volume, temperature, operating pressures, dew point, composition of the dust and dust loading as well as the particle size range of the dust to be collected. For existing plants, these can be determined by testing.

Basic Hood Design — required sufficient knowledge of a process or piece of process equipment so that the most efficient hood or enclosure is installed. While it is almost impossible to generalize, there are certain industry standards that have been proven by repeated application. For example, ventilation of screens is most effectively done by pulling approximately 50 Cubic Feet of air per square foot of screen area down through the screen cloth, the pipe connection being made to the hopper of the screen. Virtually all *crushers* are ventilated by inducing a suction down through the crusher and concurrent with material flow. Suction is induced by a hood and pipe connection to the discharge enclosure. Volume naturally varies with the size and type of crusher. If the *bulk stored raw material* or *finished product* is in an enclosed bin, the merest whisper of air will insure a completely clean operation. *Elevators* are usually vented at or near the top with sufficient air to keep the boot clean. Conveying equipment is vented from proper hoods and enclosures around transfer points. The volume varies with the size and type of conveyor.

The *bagging operation* is a relatively simple dust collecting job providing the dust source is properly hooded and an adequate volume of air is vented. After this hood design has been determined, volumes are calculated from the known open area of the hood and the selection of the captured or indraft velocity that is sufficient to prevent the outward escapement of dust. Then, the pipe size selected will have a cross-sectional area that when handling the proper hood volume the velocity in the pipe will be sufficiently great to insure that the air-borne dust does not settle out. *Branch Pipes* should be joined to a main trunk line at angles not exceeding 30 degrees with the cross-sectional area of the pipe resulting from the joining of two or more pipes being equal to the sum of the cross-sectional area of the joined pipes. If possible, it is well to avoid extremely long pipe runs for even though the static pressure requirements of the system can be calculated, the balancing of velocities in branch runs becomes an extremely difficult task.

Again refering the *Dryer Operations,* a specific volume of air and a specific temperature can hold a specific amount of moisture. The operation of the dryer then must be controlled. If the air leaving the dryer is in a near saturated state, then the natural cooling that takes place in the air conveying system, that follows the dryer will cause condensation. This builds up sticky wet dust in the piping and dust collecting equipment. Subsequently, the air flow is reduced which, in turn, reduces the efficiency of the dryer causing the condition to become more critical and eventually the entire system plugs causing a major shut-down.

Dust collection and air handling equipment is designed to work under a relatively constant volume. Constant volume is necessary to maintain air velocities above a settling out point. If there is sufficient heat and air to handle the maximum moisture condition of the material, then the condensation is eliminated. Insulation of pipe runs in dust collectors may be necessary but even the insulation will not help if the air is allowed to attain a near saturated or saturated state.

New Plants — When a new plant or plant expansion is being planned, the dust collection engineer should be called in as the process is being formulated. He can be of great assistance in checking plant layout to see that there is enough room for the installation of the dust collector and that air handling equipment is sized to include the extras that are necessary for good dust collection practice.

There are several factors to be considered in arriving at the best choice of dust collectors for a particular application.

1. *Consideration of Particle Size and Concentration* to the dust collector is of extreme importance. The dust concentration may well vary from 1/10 of a grain per cubic foot to 100 grains per cubic foot of gas. The particle size can range from ½ micron and smaller to 100 microns or more in size. One micron is one twenty-five thousandth of an inch and 44 microns is approximately 325 mesh.

2. *The degree of collection efficiency required* is another factor that will determine the type of dust collector to be used. This, of course, brings in the factors of plant location, the nature of the contaminate, its salvage value, etc.

3. One factor that may not be given sufficient consideration is the *dust loading* itself as related to the volume and dust concentration. Some recent air pollution codes that are related to pounds of dust per day in the effluent would certainly indicate that 50% collection of low grain loading in low volume may well be satisfactory while 98% of high grain loading in high volume may fail. It must be remembered that visibility of an effluent from a stack will be a function of the light reflecting surface area of the escaping material. Surface area per pound increases inversely as the square of the particle size which means that at times the removal of 80 to 90% of the dust loading could remove the coarse particles without materially altering the coloration of the stack discharge. Of course, the *physical characteristics* of the air or gas stream have a definite bearing on the equipment selection. Temperatures of air or gas above 180° F. for example, will preclude the use of standard cotton media in fabric collectors, particularly if the products of combustion are present. Water vapor at or near the saturation point could cause plugging of the air or dust passages in both fabric and dry centrifugal collectors. Various chemicals can attack fabric or metal in dry collectors and cause extremely corrosive conditions when mixed with water vapor at near saturation condition. In some cases, the more addition of water to a system will cause an extremely corrosive effect on the metal in the dust collector.

The dust to be collected has an affect on the equipment selection. *Chemical composition of the dust* can cause reactions that attack the collector elements or corrode the collector itself. Sticky materials can adhere to the collector elements and plug collector passages. *Abrasive materials* can cause wear to the degree that may well rule out the use of standard materials in the dust collector. *Particle size and shape* can rule out certain types of collectors.

Types of Dust Collectors—There are many types of dust collectors in the market today. The most commonly used in the process industries today are the heavy duty cyclones, fabric type dust collectors, scrubbers or hydraulic washers and electric precipitators. Sometimes these collectors are used in combination. Ordinarily, air cleaning equipment such as air filters, air washers and precipitron type of precipitators are not applicable to the heavy dust concentration of the process industries, and it is a rare occasion when the baffle chamber or low velocity settling chamber is used in present day practice.

The concluding portion of this paper will deal with a brief description of the process industry dust collectors.

A. *Electric Precipitators* — The electric precipitator is a heavy duty high voltage type collector in the high efficiency range. The principle of collection depends upon its ability to impart a charge to the dust particles in the gas stream and causing them to move and adhere to the grounded or oppositely charged collector plates. Most precipitators have a horizontal air flow with velocities from 100 to 600 feet per minute. The collecting plates are parallel elements and are constructed in various ways including corrugated perforated plates or rod curtains. The emitting electrodes are centered between the collector plates. Voltage difference between the electrode and the plate may be 60,000 to 75,000 volts. The removal of the collected dust is accomplished by rapping or vibrating the elements either continuously or at predetermined intervals. This rapping or cleaning action is generally done without stopping the air flow through the precipitator, therefore some dust loss can be expected in most operations because of the cleaning cycles.

The pressure drop of static pressure drop across this type of unit is generally a maximum of ½ inch water gauge. Collection efficiencies are high and uniform regardless of particle size. Space required for the equipment is large and the cost is high, especially on small gas volumes, say 50,000 CFM capacity or less.

Heavy dust concentration will cause a reduction in the collection efficiency. In such cases, it is recommended that a combination system be used. In that case, the electric precipitator is preceeded by heavy duty cyclone collectors.

B. *Fabric Collectors*—That high cleaning efficiency is obtained by passing a dusty gas stream through fabric at low velocity has been recognized and used for many years in air cleaning devices. There are two principle types of fabric collectors used in the process industry. The first employs a woven type fabric in the form of an envelope stocking or bag in which the removal of the dust appears to take place by straining action of the media and actually the collection of the dust is obtained by building a primary mat or screen of material on the dirty side of the media and this mat or primary filter media is the actual filtering or collecting bed.

A second type of fabric collector known as the reverse jet type continuous arrester employs a felted type of material which actually filters the air stream and is cleaned by a high pressured jet system which dislodges the material from the inside of the bag or fabric.

In the woven fabric type of unit, the primary bed of filtered material is employed for the removal of a high degree of even sub-micron size dust particles. When a new fabric is placed in service, visible escapement may occur during the initial operation until there is a build-up of a dust mat. This usually takes place in a matter of seconds. Usually, the fabric is a specially woven cotton, wool, synthetic fiber of glass cloth material varying with the type of application and the particular application requirement. The woven cloth fabric type dust collector is made in two basic designs, the first being an intermittent type unit where it is necessary periodically to stop the air flow through the dust arrester and clean the fabric by rapping, shaking or vibrating the material sufficiently to drop the bulk of the adhering dust to the dust arrester hopper. The pressure drop in this type of unit, after the cleaning period will be higher than the loss through the clean fabric, since sufficient dust will adhere to the fabric to maintain the dust mat needed for maximum efficiency. It is necessary to stop the air flow during this cleaning period to prevent the re-entrainment as well as the escapement of dust that will shake through the fabric. The rate of flow seldom exceeds 4 feet per minute and this type is often as low as 1 foot per minute and the pressure drop across this type of unit could vary from two to five inches water gauge between the beginning and end of the cycle.

The bag type dust collector just described should not be used where the process is continuous. Obviously, a process cannot be shut down while the collector is being cleaned. The *automatic type collector* was developed for continuous process application. The collector is divided into segments, sections or compartments and the cleaning cycle automatically controlled through timing devices whereby a cyclic type of cleaning is accomplished on a predetermined time schedule, one compartment at a time. This type of unit can operate continuously twenty-four hours a day, seven days a week, and are designed so that they can be maintained during continuous operation. These fabric collectors are used throughout the process industry on a very wide range of applications. The fabric units require more space than the mechanical types or other types of cleaning devices and are shipped completely knocked down, requiring erection in the field.

These collectors are limited to air conditions dry enough to prevent condensation or free moisture deposits on the fabric. The maximum recommended temperature for the cotton material being 180° F., higher temperatures up to 275° F. can be accomplished by use of synthetic materials and with the use of the new glass type cloth fabric operating temperatures are possible up to 550° F.

Collector cleaning is accomplished by agitating the fabric by rapping, shaking or by reverse air flow, or a combination of both methods.

The static pressure drop across an automatic fabric collector varies from 2 to 6 inches water gauge, depending on the type of collecting fabric employed. Dust collecting efficiencies can be virtually 100%, provided the collector is sized properly for the specific dust and dust system requirements. On extremely heavy dust loading, the use of a preliminary collector can be an advantage for it reduces the cleaning frequency requirements of the collector and result in longer fabric life.

C. *Wet Collectors* — Wet collectors are most generally used where the combination of high temperature and moisture laden gases are present. The dust is collected in a wetted form eliminating the disposal of dry collected material. However, the use of water may introduce corrosion conditions within the collector and additional problems in freezing climates. The space requirements are average for this type of unit. The pressure losses and the collecting efficiencies will vary widely with the design of the unit. There are six major types of wet collectors. They are:

1. Packed towers, which are essentially beds through which gases and liquid pass either concurrently or counter-currently or in cross flow and are used primarily for nuisance abatement of highly corrosive contaminance.
2. The static or air washer is used for heavy concentrations of

dust. In addition to the usual bank of sprays, this type of unit employs eliminating plates and flooding nozzles.

3. Wet Centrifugal Collector — There is a variety of designs utilizing a combination of centrifugal force and water contact to effect collection.

4. Venturi Type Collector that uses the Venturi or high pressure orifice for entraining dust in water particles.

5. Wet Dynamic Precipitator in which water sprays are used in place of plates for collecting the dust particles.

6. The Orifice type in which the air flow is brought in contact with a wall or sheet of water in a restricted passage to accomplish the dust collection.

D. The cyclone type collectors use the centrifugal force to throw the dust particles to the periphery of the air stream. The cyclone type collector is most generally divided into two basic groups cataloged by their effectiveness in the removal of small dust particles. First group is the cyclone collector which is more commonly applied to the removal of coarse dust from an air stream and is a precleaner to a more efficient dry or wet dust collector. The second is the high efficiency cyclone which has been developed to use higher centrifugal forces where centrifugal force is a function of the peripheral velocity and angular acceleration which result in improved dust separation efficiency with additional efficiency being obtained by the use of various modifications utilizing shave off or other design features. While the cyclone collector does not generally reach as high an efficiency on small particles as does the electric static, the fabrics or the wet type units the effective collection range is appreciable. Pressure losses in this type of collector range from 3 to 8 in. water gauge.

In conclusion, good dust collecting systems require proper dust collector selection as well as balanced system design and good hooding. A ready source of information is the dust collecting equipment manufacturer who always stands ready to assist you in arriving at a solution to your particular problem. I may also recommend the use of the following two reference books.

1. Industrial Ventilation by
   American Conference of
   Governmental Industrial
   Hygienists Committee on
   Industrial Ventilation
   P. O. Box 453
   Lansing, Michigan
2. Fan Engineering by
   Buffalo Forge Company
   Buffalo, New York

MODERATOR SPILLMAN: Thank you, Mr. Hoon.

We will now have Mr. Schneider give his part of the program.

Techniques And Solutions To Dust And Fume Collection Problems In The Fertilizer Industry

Gilbert G. Schneider

Introduction

With the unprecedented expansion of the chemical fertilizer manufacturing industry in the past ten years there have arisen a variety of problems concerned with dust and fume emission from the larger pieces of equipment being used.

Larger dryers, acidulation units, concentrators, screens, transfer points, bagging operations, and many other dust sources have had to be dealt with so that the air in the area of the plant does not become objectionable to the neighbors. In addition to larger and larger capacity equipment, we have observed in many areas the enactment of new legislation with regard to dust and fume control or more intensive enforcement of the already existing legislation.

The fertilizer industry has made tremendous strides in the past few years and is still making considerable progress in the successful elimination of dust, fume, mist, and gaseous products from the stack discharge. Manufacturers too have made substantial progress in the effectiveness of the equipment used to control stack emission. Professional societies such as The American Institute of Chemical Engineers, The American Society of Mechanical Engineers, The Air Pollution Control Association, and The Fertilizer Industry Round Table, and others have disseminated among themselves and to the industrial world all of the new information which has become available as improvements in techniques and solutions to dust control problems occur.

With the realization by industry of the importance of better and better controlled equipment, it should be of benefit to discuss the application and design of dust collection equipment. We will cover the various types of equipment applied to fertilizer plant manufacturing processes and some of the problems and considerations which must be evaluated when considering the use of dust control equipment.

Types of Equipment

In general there are four main types of air pollution control equipment in common use today. The use of a specific type of equipment is predicated somewhat upon the process involved, somewhat upon the physical characteristics of the gas which is carrying the dust, but mostly upon the degree of cleaning which is required. In the final selection of a specific type of equipment the equipment designer must have accurate information on the gas volume, the operating temperature, the amount of moisture in the gas, the type of dust, the dust concentration, and the dust particle size. As much additional information as can be obtained is always of value and, if possible, a representative sample of the dust to be collected should be obtained. Laboratory analysis of a representative dust sample is valuable in predicting the efficiency obtainable with the commercial installation.

The basic categories of equipment are:

1. Electrical Precipitators
2. Mechanical Dust Collectors

3. Bag Filters
4. Scrubbers

The following pages describe the principles of operation of these types of equipment which should be considered by the design engineer or operator in the selection of a specific type of unit.

Electrical Precipitators

This equipment involves the use of high voltage electrical current to precipitate the dust and fume particles from the gas stream. This equipment generally consists of a series of flat parallel plates which form ducts or passages through which the gas to be cleaned must pass. In the center of these ducts are found fine wire electrodes which form the discharge electrode system. This type of unit is energized by electrical equipment usually composed of a high voltage transformer and a rectifier to convert the stepped-up line voltage A.C. to D.C. From the rectifier the current to the precipitator is taken from the negative pole and the high voltage (50 KV) discharge or corona current that is observed causes ionization to take place in the vicinity of the electrode. This ionization is transmitted to the particles of dust and causes them to migrate to the oppositely charged (or grounded) collecting plate. They are precipitated on these plates and the plate is rapped mechanically so that the material falls into hoppers beneath the equipment and away from the gas stream.

This type of unit has a number of advantages which should be considered in the selection of it.

A. Can handle very large gas volumes at very low pressure drops. Pressure drop is seldom higher than 0.5″ WG.
B. Electrostatic precipitators can be designed for any dust removal efficiency.
C. Performance of electrostatic precipitators is not affected by the particle size of the dust.

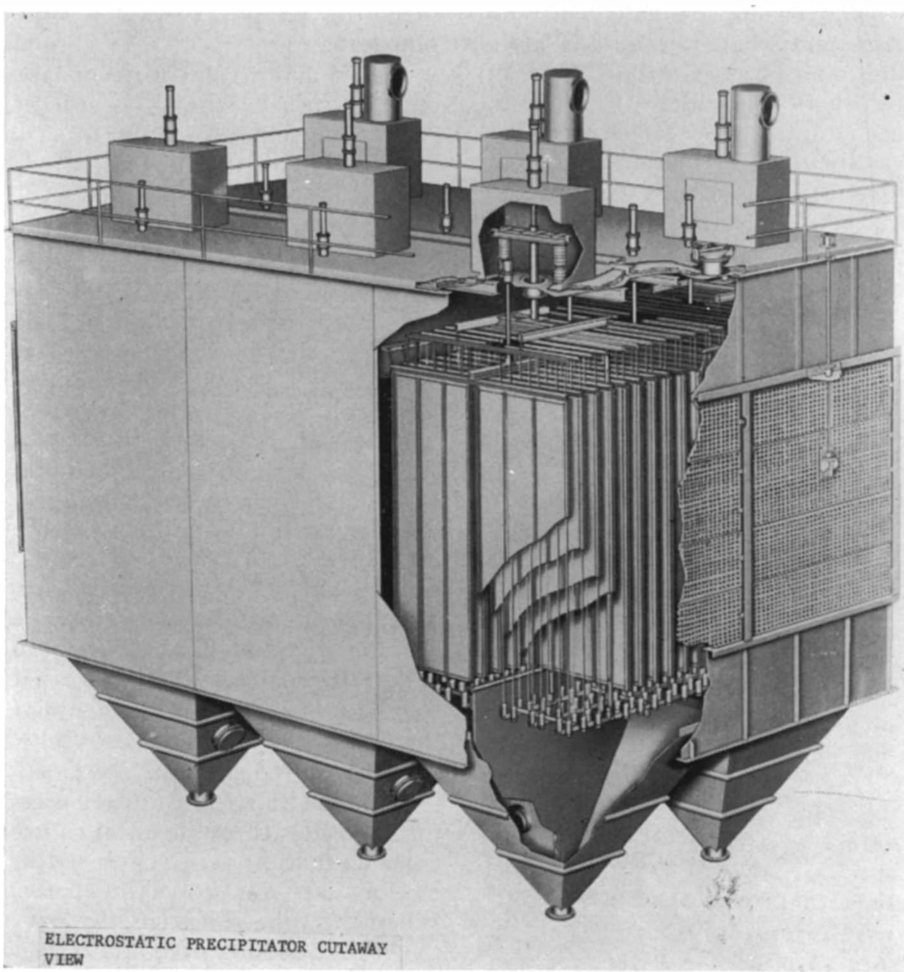
This type of equipment is recommended for use with rotary rock dryers and while there have not been a great number of units installed on this application, it has become apparent through the years that this is a relatively simple electrostatic precipitator application and one which will, from a technical or engineering point of view, be capable of simple solution if the operating conditions are relatively well specified.

A typical set of operating conditions from a rotary dryer would be:

Gas Volume	100,000 CFM
Temperature	300°F.
Dust Concentration	8 gr./ft.^{3}
Dust Particle Size	90% less than 10 microns

Equipment of this type is generally not selective with regard to the particle size of the dust — that is, the particle size distribution of the dust at the inlet is generally the same as the particle size distribution found at the outlet of the equipment.

Slide No. 1—Precipitator Cutaway



Mechanical Dust Collectors

Into this category fall the dust collectors which utilize rotary or centrifugal action to separate the dust from the gas stream. In the fertilizer industry we have relatively broad coverage through the use of large diameter cyclones and these are quite commonly found as primary "scalpers" cleaning the gases from rock dryers, calciners, fertilizer dryers, and the various ventilation sources which occur in a typical fertilizer manufacturing plant.

Advantages that should be considered in the use of this type of equipment are:

A. It is generally the least costly in terms of capital cost.
B. There are no moving parts.
C. Reasonably good efficiency on coarse dusts.
D. Compact — does not occupy a great deal of plant area per cubic foot of gas being handled.
E. Moderate pressure drop — 2″ to 3″ WG.
F. Products collected in a dry state.

There have been great strides made in the past five years in the development of mechanical dust collectors both from an efficieny and a capacity standpoint — that is, more and more efficient units have been developed that will handle more gas without sacrificing pressure drop or power consumption.

This appears to be an area in which there has been little publicity developed and the tendency in the fertilizer industry has been to more or less stay with the old line equipment without getting the benefit of some of the new developments in the field.

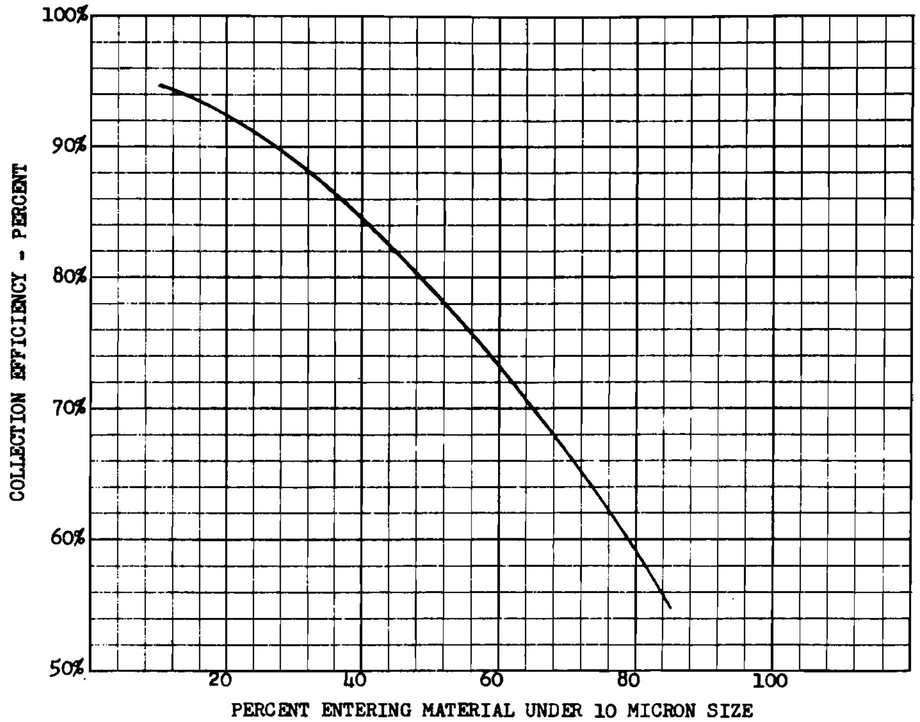
All mechanical collectors utilize a principle that exerts a force on the particles to be collected so that they are "swirled" to the outer periphery of the cyclone and discharged from the bottom of the cyclone unit. Since mass is involved in the amount of the separating force, it is apparent that cyclones' efficiency will vary as the particle size or mass. The velocity with which the particle is moved is a significant factor and the radius of curvature of the circle is also a factor.

These variables are expressed by the equation:

$$F = \frac{MV^2}{R}$$

Where: F=the separating force
M=the mass of the particle
V=the radial velocity of the particle
R=the radius of curvature of the collecting element

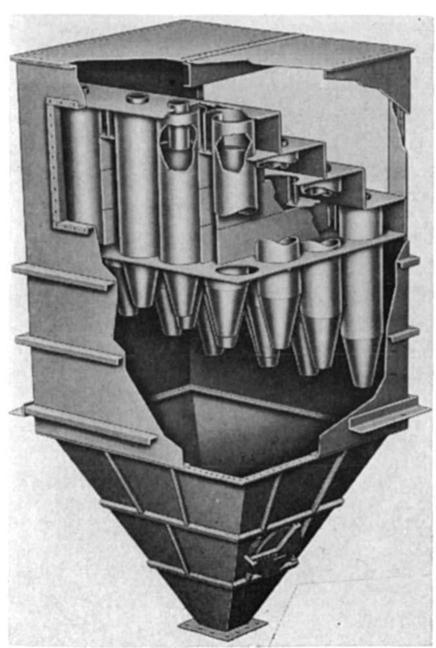
The point which is of interest here is that we can not control the mass or (within the limits of the power available) the velocity. We can, however, control the radius of curvature of the cyclone equipment and it can be seen from a routine examination of the above equation that if other things are equal, the separating force on a dust particle for a cyclone which is 120 inches in diameter will not be as great as that exerted on a particle in which the cyclone is 24 inches in diameter. This is the basic reason behind the use of smaller and smaller diameter cyclone equipment on industrial applications today. Industry use of the small diameter multiple cyclone has increased in the past ten years until this device is by far the most common piece of dust collection equipment used in industry today.



Slide No. 2—Collection Efficiency Graph

These types of collectors are most efficient on the particles which are larger than 10 microns in particle size. There is a sharp break-point in the particle size efficiency at approximately 10 microns and where the dust is more fine than approximately 40% of the material under 10 microns, mechanical dust collectors are usually used in conjunction with other equipment such as scrubbers or electrostatic treaters or they are eliminated entirely in favor of scrubbers, precipitators, or bag filters.

Slide No. 3—Mechanical Collector



To illustrate the change in efficiency of a multiple cyclone dust collector with the change in particle size, Graph No. 2 has been prepared.

Two major complaints or laments are heard frequently with regard to mechanical collectors in fertilizer plant service —

A. Low Efficiency
B. Plugging Difficulties

With regard to low efficiency we have stated above that one way to increase the separating force and therefore the efficiency of cyclone equipment is to reduce the diameter of the collecting elements. This would result in a positive increase in efficiency and is a point which design engineers should give serious consideration to in the evaluation of the equipment recommended for the process. Another point which is worthwhile keeping in mind in the operation of mechanical collectors is that they do not operate well unless there is a positive seal at the base of the hopper.

As you can see, the gas enters the collector through an involute entrance and it is given a rotary motion in the collecting tube. When the tube constricts the flow, the gas reverses its path and travels up out through the outlet tube while the dust is discharged from the collecting tube in the quiet air of the collecting hopper. There are few plants, in our observation, that have a positive air lock at the bottom of their hopper and if the unit is operated under negative pressure, a loose lock will allow air to infiltrate back in through the valve or trickle plate which is usually used. Unless there is a positive closing valve, there is always a loss of efficiency and this is a point which is seldom considered in the operation of this type of equipment.

With regard to plugging troubles, almost all of them can be relieved by the use of involute rather than vane type cyclones and proper insulation. A proper feed rate to the dryer and careful attention to startup and shut-down are part of normal good maintenance procedure to keep mechanical collectors from plugging.

Some plants use a startup procedure which involves pulling warm air through the system before the feed is started. This allows the flues and ductwork to warm up and minimizes condensation buildup of sticky material which could, and usually does, result in plugging in the mechanical collectors. Long runs of duct are to be avoided in the handling of moist gases, and even short runs should have a heavy layer of insulation to insure that condensation will not take place. This is particularly valuable in northern climates and on exposed equipment.

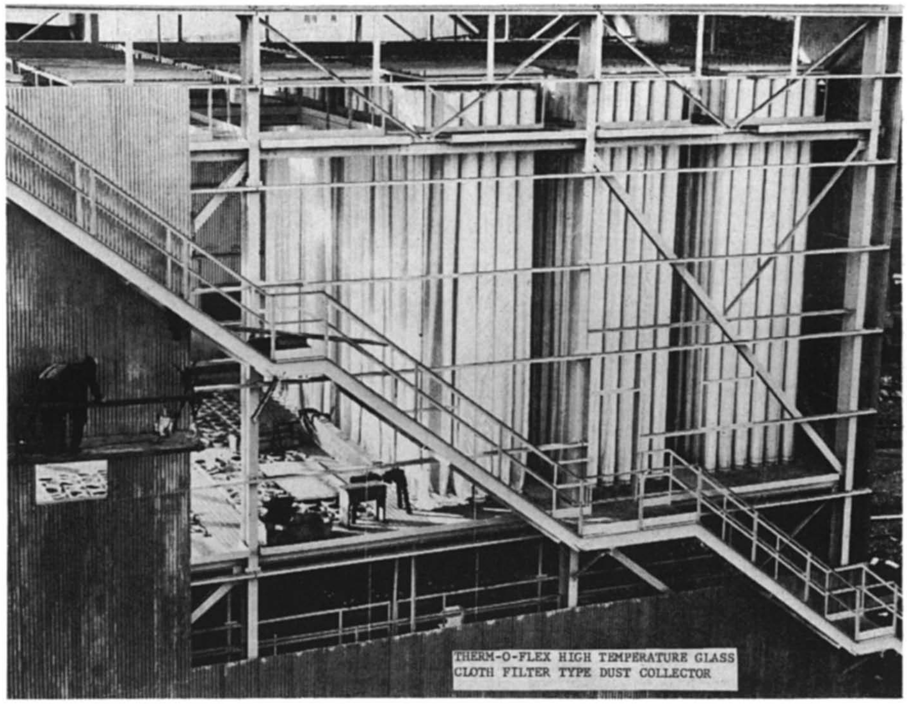
With the above provisions mechanical collectors will generally operate trouble-free on any of the fertilizer plant operations. The most sensitive operations in our experience are the fertilizer dryers and the rock dryers.

Bag Filters

Bag filters in the fertilizer industry are not a common item of equipment due probably to the reputation for severe operating conditions which is associated with this industry.

Advantages that should be considered with the use of bag filter equipment are:

A. Efficiency is virtually 100%. A particularly valuable feature in sensitive areas.



Slide No. 4—Therm-O-Flex Filter

B. Pressure drop is relatively moderate — 2″ to 5″ WG.

C. Can handle very large gas volumes as a single unit.

Bag filters have been used for the handling of rock dust from various ventilation points, crushers, screens, etc. However, their use on corrosive gases has not been common.

There have been a number of recent developments in the bag filter technology which indicates that there are broad fields of application which may be applicable in the handling of large gas volumes at relatively high temperatures such as are found on calciners or dryers. This refers to the glass bag unit in which the filter elements are fabricated from silicone treated glass bags which have a collapsing and flexing action rather than a shaking or reverse jet action to clean the deposited material from the bags. Operating temperatures on this type of equipment are up to approximately 550° F. This unit has been used on high temperature mining and metallurgy operations as well as on cement plants and there are indications that this would be a promising solution to total cleanup at fertilizer plant operations as well.

Scrubbers

Wet scrubbers are probably the most common piece of dust and fume collection equipment being utilized in fertilizer plants today. They find broad application on dryers, concentrators, agitators, acidulation units, and fertilizer dryers as well as in the various cleanup operations around a typical fertilizer plant. They have a number of features which are attractive —

A. They are generally relatively low-priced.

B. Their efficiency is high.

C. They can be constructed from corrosion resistant materials with ease.

D. They work well on fine dusts.

Since scrubbers work well on fine materials, it is not uncommon to find that mechanical collectors and scrubbers are very often "paired" into a two-stage collection system. Wet scrubbers are usually applied where the collection of the particulate matter is greater than I micron in the particle size. They operate at pressure drops which vary between 1″ and 40″ WG and their efficiency is generally a function of particle size, wetability, gas conditions, and power consumption.

Generally a scrubber is considered as being any item of eqiupment which will mix the dirty or dusty gas with water and bring the two into intimate contact. The effectiveness with which this is done is generally a function or consideration of the design of the particular item of equipment and the results which are required. For example, on a phosphate rock dryer the discharge from the cyclone precleaner is somewhere in the range of 1 to 2 grains per cubic foot. This is far too heavy a dust load to escape from the stack under any circumstances and generally secondary collectors are required of the scrubber type.

Being very finely divided, the dust is not susceptible to cleaning by further mechanical separation and generally scrubbers are required for the second stage cleaning. An impingement scrubber, such as the Doyle Scrubber with a power consumption of 6″ to 8″ WG, is capable of removing 97% or more of the dust fed to it and this amount of removal will result in an acceptable stack in almost every location.

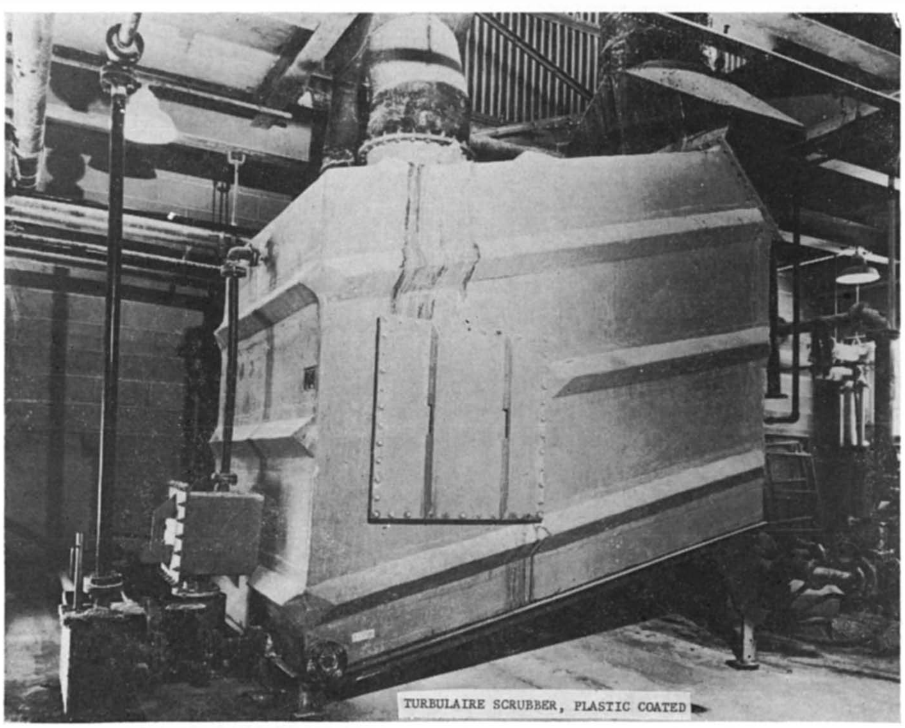
In other cases, such as on a fertilizer dryer, two-stage scrubbers are found to be applicable and in the passage of the gas through the two stages of scrubbers it generally is cooled to saturation and below saturation. The added water, which condenses from the gas stream, aids in the removal of the dust. In this "condensing cycle," the water forms around the dust or fume particle increasing the mass and making it more easily removed from the gas stream. So, in this case, we see an opportunity not only for high dust collection, but also high fume collection and the inherently longer contact time also results in good chemical absorption of the gaseous portion of the contaminants. pH control is generally easier to realize in two-stage scrubbing and this accounts for substantial collection of the ammonia materials.

Corrosion is always a problem in wet scrubbers; and, in the fertilizer industry it is almost axiomatic that rubber lined mild steel is a suitable construction material.

We have seen in the past year or so the use of epoxy resins on the less severe applications such as the second-stage scrubber and wet fan.

We have also observed the replacement of rubber lined scrubbers by plastic scrubbers of the molded polyester type. These plastic scrubbers have the advantage of being extremely light in weight, high in efficiency, and impervious to corrosive attack. While there are some special techniques which have to be utilized in the design and construction of this type of equipment, most of the difficulties have been overcome through the use of sound design or engineering principles.

Slide No. 5—Plastic Scrubber



Design Considerations

As we have observed, there are many types of equipment available to the fertilizer industry. There are also many combinations of equipment which can be utilized depending upon the amount of horsepower required, the availability of water, the dust loading, the particular process, the local topogaphy, and the local laws. It occurs to the operator that with the bewildering array of combinations of equipment to consider, it is obvious that specialized guidance is required in this field.

The primary consideration affecting the selection of the cleaning equipment is the efficiency which will be required to satisfy the operating requirements. Acidulation units having a relatively light dust load would have a different equipment orientation than would a rock dryer, for instance. Combinations of mechanical and electrical equipment are common, combinations of mechanical and scrubber equipment are common, and, as previously pointed out, one and two-stage scrubber units are utilized frequently in this field.

Conclusion

With the variety of equipment that we find in a fertilizer plant today such as rock dryers, crushers, screens, product dryers, acidulation tanks, mixing tanks, transfer points, bagging machines, etc., we find that many companies are solving their cleanup problems by staying with the old "tried and true" methods of dust and fume control. In many cases these old fashioned techniques will not keep the plant operator out of trouble with his neighbors.

It has become necessary to develop new techniques in solving more completely the problems of dust and fume collection in the fertilizer industry. These techniques have found wide acceptance in other industries with similar problems and there is every reason to believe that if, for instance, a glass bag filter operates satisfactorily on a wet process cement calcining kiln, there is every reason to expect that this same type of equipment would provide complete cleanup on a rock calciner or dryer in a similar type of industry, such as we are dealing with today.

With the bewildering array of applications and an equally bewildering array of available equipment which has been introduced on the industrial market in the past five years, it is no wonder that plant operators are occasionally confused and are unable to decide which equipment will be the best for them on each particular application. This is always a difficult decision and it is particularly difficult when the equipment is concerned with dust and fume control. That is, a fan or a pump may be somewhat under-designed or may not live up to the design efficiency and the plant can usually limp along until the item of equipment is fixed. When this same situation occurs in a dust collector—that is, when it is not operating as it is supposed to operate—the plant operator is in trouble. His neighbors complain, law enforcement people are in the plant, dust is all over the roof, and things get pretty sticky. Experience in the field then is something to look for in the application of this type of equipment. Quality of equipment, ease of maintenance, simplicity in design, high efficiency are all factors which must be weighed in the selection of the ultimate item of equipment.

There has been a tremendous expansion in the amount of equipment used in a typical fertilizer plant in the past few years. Through the use of dust collection equipment, the materials which formerly were getting out the stack are being collected; and, not only have a monetary value but also the collected material represents an investment in being a good neighbor. We can see, as a long term trend, that control legislation is progressing from the general nuisance clause to a fairly stringent set of regulations. Communities have become more and more aware that there is a solution to dust and fume problems and they are forcing manufacturers to upgrade their techniques for combating these problems. Fortunately, progressive industries such as the fertilizer industry have, in general, kept far ahead of the control legislation requirements; and, this gives added peace of mind not only to the particular operator but to the industry as well.

In the future, the science or art of designing dust control equipment will progress until we reach the point that there will be little to show in an industrial area that there is indeed a factory or a process being operated. A clean plume of steam which dissipates in the breeze will be the only indication that there is a manufacturing process going on here.

I am sure that this is a day to which we, as citizens and as industrial managers, look forward. This day is not in the far future and the technology, techniques, and solutions are available now.

Questions

1. How do you keep dust cyclones from plugging during cold weather when moisture has a tendency to condense out of the dust laden gas streams?

   Dust cyclones, and in fact all equipment exposed to cold weather, will have trouble with condensation at the wall of the piece of equipment. In some cases this is an operating problem that must be lived with. In many cases, however, this problem can be eliminated in the original design of the equipment; that is, keeping the flues short enough so that the heat of the gas is not dissipated. At the same time, a heavy layer of insulation on the flues is of benefit and we have seen many operations in which the collection equipment was housed in a "dog house" of sorts. From a maintenance viewpoint, all of these measures are worthwhile since the problems of maintenance are terrific when condensation is occurring.

2. What about dust seals for screw conveyors?

   We have recommended single flap or double flap (air lock) type of valves on screw conveyor discharges which are enclosed. Conveyors under negative pressure will operate well with this type of control and it keeps surges and puffs from runing back up the conveyor and into the hopper of the dust collector with the resultant entrainment of the collected dust.

3. Is dust during bagging more of a problem with granular goods?

   This is hard to put a definite answer on; however, almost all bagging equipment has provisions for a dust collector as part of the bagging system. The degree of severity of the problem is fairly academic since it is practically always a problem and practically always needs some type of dust collection on it.

4. Is there a successful or practical device for reducing carry-back and dribbling from a belt conveyor as it is on its return travel?

   Proper ventilation of the transfer point is a big help in reducing carry-back losses. We have seen some belt conveyors with brushes at the dumping end which are supposed to reduce this annoyance. This has been fairly successful. We have also seen one of the major conveyor manufacturers who rotates the belt after the dumping has taken place and this, too, is effective in reducing this carry-back loss.

MODERATOR SPILLMAN: Thank you, Mr. Hoon and Mr. Schneider.

We are running a little behind time. I think we have time for one or two short questions. Can we have them? (No response.)

Gentlemen, it's been my pleasure to monitor this meeting this morning and I wish to thank all the speakers for the very fine cooperation and time spent in giving their papers.

At this time, I will turn the meeting back to Dr. Sauchelli.

Business Meeting

CHAIRMAN SAUCHELLI: Thank you, Al.

We are going to have just a brief business meeting. The first item will be the report of the Secretary-Treasurer.

Dr. Marshall.

Secretary-Treasurer Report

DR. HOUSDEN MARSHALL (Secretary - Treasurer): Dr. Sauchelli, members of the Round Table. Your Secretary in the last year has sent out three notices; the first one was covering the publishing of the proceedings; the second was solicit-ing information regarding your subjects for this year's Round Table; and the third was a program resume for this meeting.

I want to compliment the membership on the returns of the questions on those postcards. It was very heartening and it helped the Committee a lot in their planning for this meeting.

I again plead with you to give us your correct address, because I don't like to pay the postman twice for one piece of mail.

Outside of that and mailing the proceedings and getting the programs together, that constituted the major part of the work of the Secretary's office.

The Treasurer's office, to put another hat on, last year as of October 31, 1960 we had on hand $999.72. From the 1960 registration we took in $3,075.00; the membership list sales amounted to $166.00. During the year 1960-'61, October this year, the sale of proceedings was $1,123.97. Some publisher took a little discount, that's the reason we had that odd figure.

The total cash in was $4,364.97. The total cash handled or in possession momentarily during the year by the Treasurer from October 31, 1960 to October '61 was $5,364.69. The 1960 meeting costs, the incidentals were $281.00. Your membership list costs were $189.69.

Now your proceedings, I think you might be interested in knowing what the cost of those proceedings amounted to. The transcript was $647.98, the printing $2,-415.54, and the mailing $280.04, making a total of $3,333.56.

Remember that cost is covered by the registration fee and the $1,-125.00 that we took in cash sales.

Your Secretarial office, the services charge was $365.00, that's typing and getting the material together; notices, postage, three notices, $123.60. Supplies, that's paper, envelopes, mimeographed sheets, mimeograph stencils and whatnot, $240.73, which amount to a cost of $729.53 imposed by your Secretary.

Making a total disbursement of $4,534.22. That, subtracted from the $5,364.69 that we handled leaves us as of October the 30th a cash balance of $830.47.

Respectfully submitted.

CHAIRMAN SAUCHELLI: Thank you, Mr. Secretary-Treasurer, for that report.

May we hear from the Auditing Committee. Mr. Rodger Smith.

Auditing Report

MR. RODGER SMITH (Auditing Committee): Dr. Sauchelli, members of the Fertilizer Round Table, we examined the records of the Treasurer and found them accurate and in order.

CHAIRMAN SAUCHELLI: I want to emphasize this thing. All this work, and it's a tremendous amount of work, has been done at very low cost. The big cost is printing and some secretarial work, but these meetings represent a tremendous amount of money. If we could add what it costs for each of the total membership here to come to Washington and its expenses and so on, we would realize that time here is very precious, every minute of our sessions here is worth a lot of money. The work of your Committee has been given free. We heard Wayne King this morning say that over the years he's been a member of an organization and it costs around $50,000 just for handling the business and so on and organizing things. So that I think we can feel a satisfaction that we're doing a job here more out of the love of it than for any financial profit.

Recognition of Trade Press

Before we go to new business and so on, I want to do something which I think heretofore we have been remiss in. I want to take this occasion to recognize a very hard-working group that has been a help to us, and I refer specifically to the members of the trade press. I would like them to stand up; I'd like to recognize them, if you please.

I know you know all these good folks. If there ever was a hard working group, that's it, and we are very much indebted to our trade press.

I can remember pretty far back and compare the standards that are being lived up to today with what they used to be, and I can say this that our trade press today is of much higher standards and we as an industry can be proud that we have a press that serves us and it is a very vital help to our industry and particularly to our Round Table to have good friends here to work as hard as they do and give us such a fine coverage.

I would say that if you look in the mirror and don't like the image you see there, you don't smash the mirror, you improve the image. The press reflects the industry and I don't think that we have to smash the mirror.

Nominating Committee Report

It is time now for the Nominating Committee. Every other year we have the business of considering the organization. The Round Table is a most informal organization.

People ask me: "How does it function?" "What's behind it?" "Who sponsors it?", and so on. Then I tell them that it's the membership itself that sponsors it, we're an informal group and we plan to keep it that way. We are not sponsored by any special organization, but we are sponsored by ourselves.

I often have said that you are the Round Table and your program, the programs that we arrange here are your programs. You act as a committee of one to tell us what kind of programs and what items you want discussed, and our Executive Committee tries to select from your requests, your suggestions, those items which we think will form an interesting and worthwhile program. I am sure it is your feeling and this is the way you want to keep it.

However, I am going to recognize Mr. Wayne King at this moment to give him a chance to have his say.

MR. WAYNE KING (The W. S. Tyler Company): Thank you, Dr. Sauchelli, Mr. Chairman. Now comes the time to formulate our informality, if you please. Even with a high degree of informality, you have to have somebody to steer the vote. I have two resolutions here; I would like to refer to this succinctly for brevity.

Now, A and B, not in any committee, consisting of some 25 people, we met this morning and we agreed on a slate. That's resolution A. I place these names in nomination and it would be a repeat of what we have now.

It consists of Dr. Vincent Sauchelli as our Chairman; Mr. Joe E. Reynolds, Jr., Mr. Albert Spillman and this will be for the years of 1962 and 1963 to be specific.

Dr. Marshall is our permanent Secretary-Treasurer, and we are not required to vote on his office at this time.

So in the absence of anyone nominating anyone from the floor — and I'll do this quick so they won't — I would like to have everyone in favor of this vote say "aye".

(A chorus of "ayes".)

Contrary. (No response.)

By whatever power may have been given to me, I declare these gentlemen elected. (Laughter.)

B, it has been my distinct privilege and pleasure to associate myself with this Executive Committee to a degree because I am interested in the elevation of brains and this is what we have here, an exchange of ideas, the elevation of brains, and the B part of this is that we wish to instruct the Executive Committee that the committee be either expanded or be given complete latitude, and have a complete year to do this in, the idea being that they will report to us then in November of 1962 and spell out what they have on it.

If there is any further idea on this, I would suggest that you give it to them in writing and I am sure that they will consider any added factor there that you have in mind.

So all in favor of that say "aye", please.

(A chorus of "ayes".)

Contrary. (No response.)

I declare that one passed.

CHAIRMAN SAUCHELLI: Thank you, Wayne.

Our Secretary has something to say about next year's meeting place and date.

Time and Place 1962 Meeting

SECRETARY MARSHALL: Next year we have an unfortunate situation in that our date is a little earlier; it's in October. That is because in this hotel and all the hotels in Washington there is a large home association or something or other coming in, and they have captured all the rooms, but I will state to you here and now that that will not occur again, because I fortunately was over here one day when they put the new sheets in the book upstairs and we have it straight through to 1970, the first or second week, depending upon election, from there on in this room. But for next year we have to move back to October 24, 25 and 26; that's Wednesday, Thursday and Friday of the third week of October. We regret that very much, because we realize that's getting close to some of the other meetigns that take place in October, but can't help ourselves.

I think we ought to entertain a motion to accept those dates, because I do have to notify the hotel today.

CHAIRMAN SAUCHELLI: May I suggest that in this connection we have explored the possibility of holding a meeting in other cities and the result so far has been very unfavorable, even though I know that the majority here have always voted for holding the meeting in Washington. But we just wanted to look around and see if we could report something to you, but it is just as difficult in some of these other cities. We thought about Cincinnati, St. Louis, and even Kansas City and Chicago, but the situation is as bad as it is here in Washington. Washington is a terrible place to get space in the hotels, unless you're about five years ahead, because it is a favorite convening place and people like to come to Washington.

What is your wish with regard to next year here on the dates specified by our Secretary?

A MEMBER: I move we accept the dates Dr. Marshall announced.

CHAIRMAN SAUCHELLI: Is there a second?

(The motion was seconded.)

You have heard the resolution. All in favor say "aye".

(A chorus of "ayes".)

Contrary. (No response.)

It is carried.

Recognition of Visitors From Foreign Countries

I want to take this opportunity now to recognize some of our visitors from foreign countries, and I hope they are in the audience now. We have two friends from Australia who are here. Mr. John Schroder and Mr. Tudor Mackay. Are they here?

(Mr. Schroder and Mr. Mackay arose; applause.)

We are always pleased to have visitors from overseas and we have been fortunate in having visitors each year to come to these meetings.

We have, I believe, many friends from across our northern border. We really don't look upon them as foreigners, but we have our Canadian friends and I would like to have them stand up.

(The Canadian members arose; applause.)

We have registered a large delegation from Canada and we, of course, welcome them as our real fine friends.

Is there any new business to come before the group?

(No response.)

If not, we stand adjourned until this afternoon. I want to say that I regret I won't be able to be with you for the rest of this meeting. I have a commitment in Taiwan so I am leaving tomorrow.

Thank you.

Enthusiastic applause for Dr. Sauchelli.

(The meeting adjourned at twelve o'clock p.m.)

Thursday Afternoon Session, November 9, 1961

The Round Table reconvened at two o'clock p. m., Mr. J. E. Reynolds, Moderator, presiding.

MODERATOR REYNOLDS: Ladies and gentlemen, I would like to welcome you to the afternoon session. We have a feeling that we keep rushing these programs. We apologize for it, however; if we can get started on time we will try to get you out by five o'clock this evening. This will be a real effort and we will do our best.

A recent survey reported in Crop Life Magazine tabulated data relating to ammoniation-granulation practices in our industry. From the information compiled, it became apparent that some interpretation of these statistics would be most helpful. To accomplish this, we requested a representative of the Tennessee Valley Authority to study the data and give us a summary of process equipment, the practices and variations in our industry.

Mr. Al Phillips, Director of Process Engineering, Branch of TVA, will discuss this subject.

Croplife Survey of Continuous Ammoniation Practice

Alvin B. Phillips

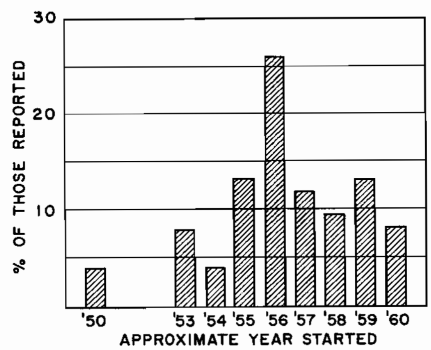
Introduction

LAST year at the Round Table Meeting, Larry Long, Editor of Croplife magazine, first mentioned to me his idea that Croplife conduct a survey of the users of the TVA continuous ammoniator to find out what is standard practice in the use of that equipment. He reasoned that the information gained by such a survey would be of interest to the industry and would be helpful in spreading the knowledge gained by years of experience in operating this equipment. He asked that we at TVA help prepare a questionnaire for the survey. Naturally, we, were quite enthusiastic about the project and were glad to cooperate.

A list of some 31 questions was prepared and sent by Croplife to all the companies that were licensed by TVA to use the continuous ammoniator process. By March 1961, 53 questionnaires had been returned and the results were compiled and published in the March 1961 issue of Croplife. Subsequently, a total of 77 replies was received and these were compiled at TVA to give the information that I have been asked to present today. I hope that you who operate continuous ammoniators will be interested to see where your operation fits into the over-all picture.

First, a few general remarks about the results. The annual production of the plants represented by the 77 replies is estimated to be in the order of 2 or 3 million tons. Taking into account that some of the replies cover more than one plant operated by the same company, we estimated that roughly 50% of all the ammoniators we know to be in existence are represented, which means we have a good-sized sample.

The average age of the plants reporting was 4½ years; the oldest was 11 years. You might be interested in the first slide which is a



AGE OF CONTINUOUS AMMONIATOR PLANTS

Slide 1

bar graph indicating the number of plants reporting that were started in a given year. This graph shows that the rate of building continuous ammoniators has been fairly steady since about 1955 except for the peak in 1956.

One of the most startling things revealed by the survey was the very large number of different fertilizer grades made in the continuous ammoniator. One question asked the respondents to list the five most important grades made in their plants. No less than 89 different ones were mentioned. This doesn't mean that a total of only 89 grades was made in the plants. It means that each of these 89 was among the top five in at least one plant. The most frequently mentioned grades are shown in the next slide in the order mentioned — 5-20-20, 12-12-12, 10-10-10,

Slide 2

Most Important Grades and Ratios[a]

Grades			
(1)	5-20-20	(6)	5-10-10
(2)	12-12-12	(7)	4-16-16
(3)	10-10-10	(8)	10-20-10
(4)	6-24-12	(9)	6-20-0
(5)	6-24-24	(10)	3-12-12

Ratios	
(1)	1-4-4
(2)	1-1-1
(3)	1-2-2
(4)	1-4-2
(5)	1-2-1

[a]Mentioned most frequently among top five.

6-24-12, and 6-24-24 were the top five. Each was put in that category by 20 to 50% of the plants. The next five grades most frequently mentioned are shown on the right —5-10-10, 4-16-16, 10-20-10, 16-20-0, and 3-12-12. The five most important ratios are shown below—1-4-4, 1-1-1, 1-2-2, 1-4-2, and 1-2-1 in that order. When you consider that the two most popular ratios are those having directly opposite granulating characteristics, it's small wonder that plant superintendents have headaches.

Ammoniator Details

Let's have a look now at some of the details of the ammoniators. There was quite a variety of sizes reported, ranging from 4 to 8 feet in diameter and 6 feet to 16 feet in length. The next slide shows the

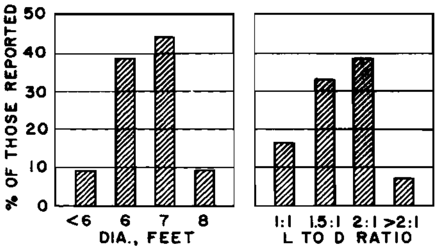
Slide 3

Size of Ammoniators

Dia. x Length, Ft.	% of Those Reported
7 x 14	20
6 x 8	12
6 x 12	11
7 x 10	10
7 x 8	9
6 x 10	9
6 x 6	5

seven most frequently mentioned sizes listed in order. They were 7 x 14, 6 x 8, 6 x 12, 7 x 10, 7 x 8, 6 x 10, and 6 x 6. They account for about 75% of all those reported.

The next slide shows two bar graphs. The one on the left gives the distribution of diameters and the one on the right, diameter to length ratios. As you see, 6- or 7-foot diameter ammoniators with



DIMENSIONS OF AMMONIATORS

Slide 4

length to diameter ratios of 1.5 or 2 to 1 are the most popular.

The reported speed of the ammoniators also varied widely, ranging from 4 to 16 r.p.m. However, the average was about 30% of the critical speed. The critical speed is that at which material would be carried around the drum by centrifugal force. It is calculated by dividing 76.5 by the /diameter of the drum. Thirty per cent of the critical speed is about 9⅓ r.p.m. for a 6-foot-diameter drum and about 8 r. p. m. for an 8-foot drum.

Most ammoniators contain retaining rings equal in height to 15 to 30% of the diameter judging from the replies to the survey.

Stationary scrapers are most frequently used for cleaning the shell of ammoniators although mechanical knockers are often used. A few contain moving scrapers.

The majority of plants—about 80% in fact—do not have separate granulators. In most of these plants from 25 to 50% of the length of the ammoniator is used for granulation. Very few use more than 80%, or less than 50%, of the length for ammoniation.

The survey showed that the majority of operators have adopted the simple drilled pipe design for distributing ammonia or ammoniating solution. The next slide

Slide 5

Type of Ammonia or Solution Sparger Used

	% of Those Reported
Drilled Pipe	60
Block	11
Slotted Lip	9
Various Others	20

shows the preference in sparger design. Sixty per cent use the drilled pipe; 11% use a block sparger; and 9% use the slotted-lip type that was the original TVA design. The remainder use a variety of types that were hard to classify.

The best material of construction for the acid sparger has long been a "bone of contention" in ammoniator design. It was difficult to separate acid spargers from ammonia spargers in the survey data, but the next slide shows our best

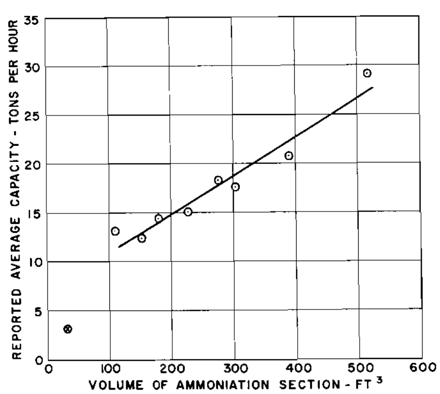
Slide 6

Material of Construction of Acid Sparger

	% of Those Reported	Average Life, Mos.
Mild Steel	42	½
Hastelloy C	39	22
Stainless Steel	15	11

estimate of the practice. Of the three materials used, mild steel or black iron is the most frequently encountered; the average life reported was about 2 weeks. Hastelloy C runs a close second but of course has a much longer life—the average was 22 months — and several "indefinite's" were reported. Stainless steel was used in only 15% of the plants and had an average life of 11 months.

The capacity of the ammoniators varied quite widely. The reported average production rate was from 8 to 32 tons per hour. There was a significant correlation of the capacity with the volume of the ammoniation section. This correlation is shown on the next slide.



Slide 7

Each point shown on the graph represents the average of about ten replies to the questionnaire. There was a considerable amount of scatter in the individual data points. The "X" point at the lower left represents our pilot plant.

We tried correlating the capacity with various other parameters that included rotational speed, total volume, length to diameter ratio, or other factors, but found no other valid correlations. This is not to say that they do not exist — in all probability they do — but the data from the survey were not precise or inclusive enough to show them. It would take a much more detailed questionnaire to obtain the information needed for work of this type. I wish that the data at hand had been more useful in this respect.

Control of Granulation

As most of you know, the main problems in control of granulation in the continuous ammoniation process are inducing the low-nitrogen grades to granulate and preventing the high-nitrogen grader for overgranulating. Several questions were included in the survey to determine how these problems are most often solved in large-scale plants. The results are shown in the next slide.

Slide 8

Method of Control of Granulation

High N Grades:	
Limit Solution Rate	61
High Recycle Rate	56
Air	8
Other	11
Low N Grades:	
Water Addition	78
Granular Potash	74
Excess Acid	57
Steam	23
Other	8

In the high-nitrogen grades, as illustrated by those of the 1-1-1 ratio, the most popular method of control of granulation, as you might expect, is limiting the amount of ammoniating solution in the formulation and increasing the amount of nitrogen from a solid source. Sixty-one per cent of the plants use this method. A close second is the use of a high recycle ratio to control granulation — used by 56% of those reporting. A few—8%—use air for control.

Incidentally, the percentages shown add up to more than 100 because some respondents reported using more than one of the methods. However, 65% reported using only one. Twenty-five per cent use two, and all of those who reported using air for control use at least one of the other methods as well.

The addition of water is the most popular means of promoting granulation of 1-4-4 grade, although granular potash is used for this purpose almost as widely. Somewhat more than half of the plants use excess acid in the formulation to induce these grades to granulate. About one-quarter are equipped to add steam as an aide to granulation. Practically all of the respondents report using not only one, but two or three of these methods. Some use all four shown.

Auxiliary Equipment

Turning to auxiliary equipment used in the plants, 14% of those reported use preneutralizers. As might be expected, most of those having preneutralizers reported high-nitrogen grades of 12 units or more at the top of their lists. Most of these did not report limiting the solution rate to control granulation, so it appears that the preneutralizers are doing at least a part of the job for which they are intended.

Fume scrubbers are installed on the exhaust stacks of about half of the ammoniators, according to the survey.

The dryer sizes reported ranged from 4 to 10-½ feet in diameter and 20 to 70 feet in length. However, 75% were between 6 and 8 feet in diameter and about 35 to 55 feet in length. Although some of the dryers seemed small for the reported capacity, very few listed poor drying as a major problem. Slightly less than 10% of the plants operate with no dryers at all. Co-current dryers outnumbered the countercurrent type 3 to 1.

My next slide shows the extent

Slide 9
Extent of Drying

Moisture, %	% of Those Reported	
1 or Less	58	16
1.5 to 2.0	36	64
2.5 to 3.0	6	15
>3.0	0	5
Ratio	1:1:1	1:4:4

to which products are dried. The majority of operators (60%) dry the 1-1-1 grades to 1% moisture or less and the 1-4-4 grades to 1.5 to 2.0% moisture. I was somewhat surprised to find that in 40% of the plants the 1-1-1 grade products contain between 1.5 and 3% moisture — also, that only 18% of the respondents use conditioner on their products.

Coolers reported ranged from 4 to 9 feet in diameter and 12 to 60 feet in length. However, about two thirds were 6 to 8 feet in diameter and 30 to 45 feet in length. Inadequate cooling was not listed among the major problems of very many operators, although a few with the smaller coolers did mention cooling problems.

We find also that the screen area provided in granulation plants varies widely, ranging from as little as 24 square feet to about 100. The average of those reported was about 50 square feet. The next slide shows the mesh size on which

Slide 10
Screen Mesh Size

Size, Mesh	% of Those Reported
6 x 16	30
6 x 20	10
7 x 14	10
6 x 14	8
15 Other Combinations	42

the products are screened. As you see, 6 by 16 mesh has become the most popular size, accounting for 30% of those reported. Next are 6 by 20 and 7 by 14 mesh, with 10% each; and 6 by 14 was reported by 8%. No less than 15 other combinations ranging from 7 by 12 to 5 by 28 mesh were reported by the remaining 42%.

Turning to the more subjective part of the survey, we asked whether nitrogen loss was considered a serious problem and if so, what was believed to be the main cause of the loss. Exactly half of those who replied to this question reported that nitrogen loss was not a serious problem. Most of those who did report that nitrogen loss is a serious problem consider ammonia or fume loss the main cause. About 25% mentioned losses during drying. Unfortunately, we could not relate the incident of nitrogen loss with other data obtained from the questionnaires, as we had hoped to do when we proposed this question.

When asked how they would change their ammoniators if they were installing new ones, 65% of the respondents replied they would make them longer; 5% said they would make them larger in diameter; and 7% would increase both the length and diameter. Fifteen per cent would make no change at all and 8% would use an entirely different type.

The last question of the survey was concerned with difficulties in operating the equipment. The respondents were asked to describe their main difficulty. Some of the answers, which I will run through quickly, should be of particular interest to equipment manufacturers.

Two problems were mentioned much more often than any others. The foremost of these was maintenance of equipment; this was followed by difficulty in control of the process, or more specifically, control of granulation.

The problem of training personnel to operate the equipment properly was listed next often, and in some cases quite emphatically—this was emphasized in Croplife's report of this survey. Then came difficulty in maintaining analysis, followed by nonuniformity of raw materials — a subject to be discussed in detail later this afternoon.

Drying and cooling problems were mentioned next often, followed by fume control, metering, screening, and plugging of cyclones, in that order.

Seven respondents did not answer this question. I don't know whether this means they have no problems, or that they found them too numerous to single out the main one. Two fortunate people did declare, however, that they have no important problems!

In conclusion, I should like to thank Croplife magazine for permitting me to use the data given inthis report and to thank the plant personnel — many of whom are in this audience — for taking time to complete and return the questionnaire.

Certainly, the survey revealed much interesting information that would be difficult to obtain in any other manner. I hope it will give some of you some ideas for improving your operation. Without question it shows that there is little standardization in equipment and operating practice in continuous ammoniation plants. It also shows —by the number and detail of the responses — a commendable desire of the members of the industry to share information with one another.

MODERATOR REYNOLDS: Thank you, Al.

Let's have some questions. I'm sure this most interesting report has prompted some questions.

We will move along to give you a chance to think up some questions and maybe we'll come back to them later.

We do have some announcements here.

We'll move along to our next speaker.

The industry trend toward high analysis is continuing. With initial granulation six to seven years ago, one of the strong points for granulation was the reduction of caking tendencies. More concentrated plant food most often means the use of more hygrascopic raw materials. We are now back to the need for review of conditioning and anti-caking agents.

We are most fortunate today to have as our speaker Mr. John Hardesty, Senior Chemist for the U. S. Department of Agriculture, who will bring us up to date and speak on fertilizer conditioning, current progress and problems.

Fertilizer Conditioning — Current Progress and Problems

John O. Hardesty

CONDITIONING of mixed fertilizers for the purpose of decreasing their caking tendencies is a continuing problem of the fertilizer industry owing to the wide range of physical and chemical conditions under which fertilizers are made, stored, and transported. Earlier studies of the mechanism of caking (7, 11) have shown that caking is the result of crystal knitting and that crystal knitting can be largely controlled by limiting the proportion of highly soluble salts in the mixture, drying and cooling the product before storage, and by storing the product in such a manner as to avoid high mechanical pressure in bulk- and bag-storage piles (5, 6, 11).

Another procedure for inhibiting caking, especially of granular products, is to control the moisture-temperature relationships during processing so that, with adequate mixing, virtual completion of chemical reactions that occur between the components can be accomplished in the retention time provided. The effects of processing with different types of ammoniating solutions on the physical condition of mixtures were discussed at the 1959 meeting of the Fertilizer Industry Round Table (4).

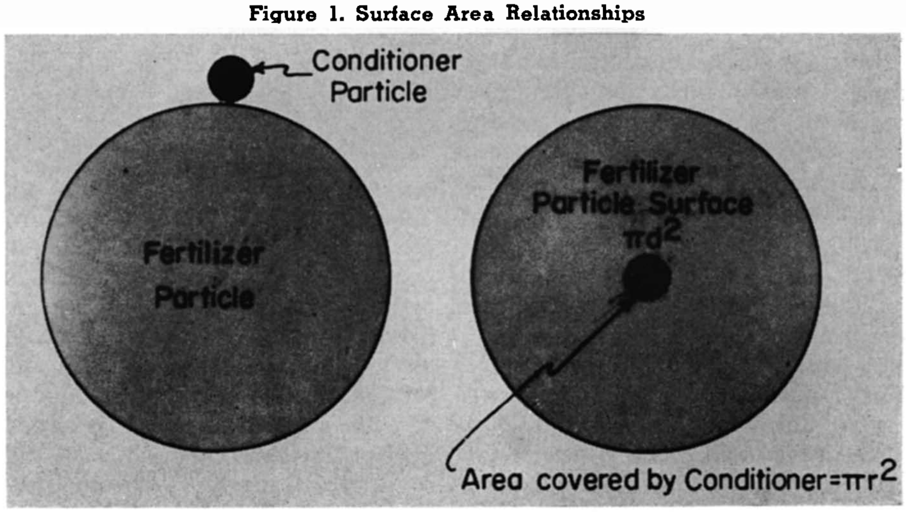
Granulation makes possible the satisfactory use of many high-analysis mixtures that otherwise could not be used because of poor physical condition. However, the alleviation of caking through enlargement of the particle size by granulation has been partially offset in recent years by the introduction of high-analysis fertilizers containing exceedingly large proportions of highly soluble salts. Attempts to improve the physical condition of such products have led to the use of powdered coating agents. It should be emphasized, however, that conditioning agents become of practical value only after suitable formulation and processing techniques have been used to prevent severe caking of the product. Mixtures with a moderate caking tendency yield to conditioning agents (5). The use of conditioners in such mixtures can make the difference between products that are non-drillable and those that are entirely free-flowing. A consideration of the properties of the conditioner and of the fertilizer is essential to the efficient and successful use of conditioners. The present discussion deals with the relative particle size and density of both the powdered coating agent and the fertilizer, the experimental use of some relatively new types of conditioning agents, and a recent development in the technique for determining the caking tendency of fertilizer.

Powdered Coating Agents

It has been demonstrated (6) that the conditioning effect of finely-divided coating agents, such as siliceous powders, diatomaceous earth, and clays, is closely related to particle size and density. For the sake of simplicity in estimating the amount of conditioner required to coat a fertilizer, it is convenient to assume particle sphericity and equivalent density of the fertilizer and conditioner, and to ignore errors arising from dealing with curved surfaces. The approximate percentage of conditioner required to cover a unit mass of fertilizer then may be calculated from average values for the diameters of the respective particles.

Accordingly, a particle of conditioner on the surface of a fertilizer particle may be represented (Figure 1) by the area of a circle

Figure 1. Surface Area Relationships



(πr^2_c) superimposed on the surface area of a sphere (πd^2_f), where r_c is the radius of the particle of conditioner and d_f is the diameter of the fertilizer particle. The approximate number of particles of conditioner average 10 microns in diameter ($d_c = 10$, $r_c = 5$) required to cover the surface of a single particle of 8- to 10-mesh fertilizer averaging 2000 microns in diameter (d_f=2000) is therefore $\pi d^2_f / \pi r^2_c$= 4,000,000/25, or 160,000. The number of particles of conditioner having a diameter of 10 microns and a total volume equivalent to that of a particle of 8- to 10-mesh fertilizer having a diameter of 2000 microns may be represented by the ratio of the cubes of their respective diameters, d^3_f/d^3_c=8,000,000,000/1000, or 8,000,000. Thus 160,000/8,000,-000,=.02, or 2% of the conditioner is required to cover the fertilizer particle.

Figure 2 shows the approximate percentage of conditioner of varying particle size required to cover a unit mass of 8- to 10-mesh fertilizer. The illustration shows that, for each 10-micron increase in average diameter of the conditioner, the quantity required to cover the fertilizer with a monolayer coating, increases by 2 percent, or 40 pounds per ton of fertilizer.

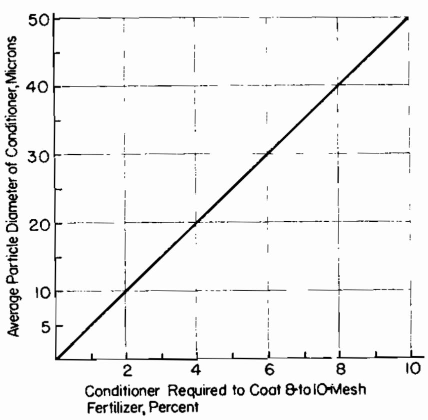


Figure 2. Conditioner Required vs. Particle Size of Conditioner

Figure 3 illustrates the effect of the particle size of the fertilizer on the proportion of conditioner required to give adequate coating and conditioning of the product. The requirement for conditioner having an average diameter of 10 microns is 4 percent when the average particle size of the fertilizer is 14 to 20 mesh and about 16 percent when it is 48 to 65 mesh.

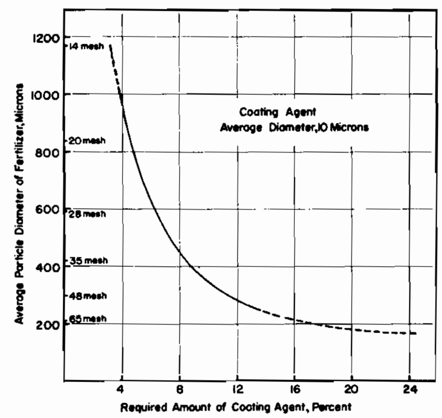


Figure 3. Conditioner Required vs. Particle Size of Fertilizer

Table I illustrates the effect of particle density of the conditioner on the proportion required to coat a unit mass of 8- to 10-mesh fertilizer. The proportion required decreases in direct proportion to the decrease in density because a decrease in density gives a corresponding increase in the number of particles per unit mass of conditioner.

Table I. Effect of Density on the Proportion of conditioner Required to Coat 8- to 10-mesh Fertilizer

Average particle diam. of conditioner	Proportion of conditioner required Ratio, conditioner density/ fertilizer density		
	1/1	1/2	1/6
Microns	- - - - -	percent	- - - - -
56	11	5.6	1.87
50	10	5.0	1.67
40	8	4.0	1.33
30	6	3.0	1.00
20	4	2.0	0.67
10	2	1.0	0.33
5	1	0.5	0.17

Oil Coating Agents

van den Berg and Hallie of The Dutch State Mines in The Netherlands have developed a process (*12*) of prilling calcium nitrate by congealing, or crystallizing, the prilled droplets in a column of mineral oil. The prills are centrifuged and bagged immediately. The procedure gives a product having less than 0.5-percent of oil coating uniformly distributed at the surface of the particle. The product is reported to have good physical condition as compared with unconditioned calcium nitrate. Such a procedure provides intimate contact of fertilizer and conditioner, which is not readily obtained with the use of powdered solid conditioners, or even with the spraying of liquid conditioners on the fertilizer.

Fatty Amine Chemicals

The importance of uniform distribution on the separating- or coating agent at the surface of the fertilizer particle is exemplified in the excellent conditioning effect of fatty amine chemicals when they are used as flotation agents in the manufacture of potassium chloride. The conditioning value of fatty amine-type chemicals, having the general formula of $R\text{-}CH_2\text{-}NH_2$, has been recently demonstrated in laboratory experiments and plant-scale tests with crystalline salts and granular mixed fertilizers (*2*) which were sprayed with as little as 0.05 percent of the conditioning agent. The chief problem in the use of these chemicals, as in the case of powdered conditioners, is that of obtaining uniform distribution of the conditioner at the surface of the fertilizer particle. The procedures of spraying and dusting appear to require greater attention to techniques for obtaining uniform distribution of the conditioner than do those which give prolonged intimate contact of the conditioner and fertilizer, such as the flotation of potassium chloride with fatty amine chemicals or the prilling of calcium nitrate in oil.

Water-Repellant and Impermeable Coatings

Vinyl acetate, waxes, resins, paraffin, and polyethylene coatings have been applied experimentally on the surface of the fertilizer particle for the purpose of controlling the release of nutrients to the growing plant (*8, 9*). Coatings of this type should improve the physical condition of the fertilizer but, here again, a major problem is one of obtaining uniform distribution of the coating. Much more research is needed on the methods of coating and the use of the coated products before the process can be considered commercially feasible.

Caking Tests

Large-scale bag-storage tests in the factory consume considerable time and large quantities of test material. They are difficult to control because of the large number of variables involved. Results of tests on the same test material will vary with the climatic conditions under which the tests are made. On the other hand, laboratory caking tests are more rapid and require only a small amount of test sample. Variables such as moisture content, temperature, and mechanical pressure on the sample can be controlled. The test results can be correlated with those obtained under varying storage conditions in commercial practice.

The laboratory procedure for determining caking tendency normally involves storing the test sample for a given period of time under controlled conditions of temperature, moisture content, and mechanical pressure, followed by crushing-strength tests on the resulting fortilizer cake. Typical methods are those of Adams and Ross (*1*), and Davies, Ditcham, and Greaves (*3*) as modified for granular fertilizers, first by Whynes and Dee (*13*), and more recently by Nunn (*10*).

In the latest technique of Nunn, the pressure is applied by compressed air to the outside of a thin Neoprene sleeve containing the sample of fertilizer. Equipment for preparing the test specimen is shown in Figure 4. The procedure

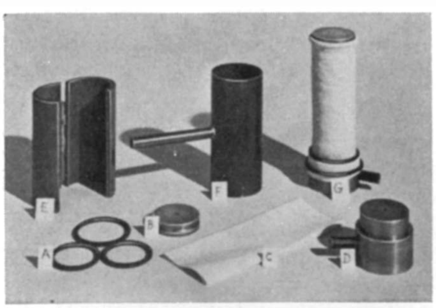


Figure 4. Equipment for Forming the Specimen Courtesy, Fisons Fertilizers Ltd., (10).

for forming the completed specimen (*G*) is briefly as follows: place two of the rubber rings (*A*) in proper position on the cylinder (*F*); stretch the Neoprene sleeve (*C*) on the inner wall of cylinder (*F*), turning the ends of the sleeve back over the outer wall; place the assembly on the base (*D*), rolling the end of the sleeve and rubber rings down over the base; pour the required amount of test fertilizer in the assembly and place the disc (*B*) in position to cover the fertilizer; unroll the top of the sleeve and remove the cylinder; roll the remaining rubber rings and top end of the sleeve into position on the disc, using the hinged cylinder (*E*) to position the disc. The base (*D*) is vented to the atmosphere so that when pressure is applied to the outside of the elastic container the sample inside is under atmospheric pressure and the applied pressure will be transmitted from granule to granule through the mass as in a bag of fertilizer. The base vent is connected to a copper manifold accommodating 10 samples in a glass pressure chamber operating at 6 p.s.i. and 35° C. (Figure 5). Two

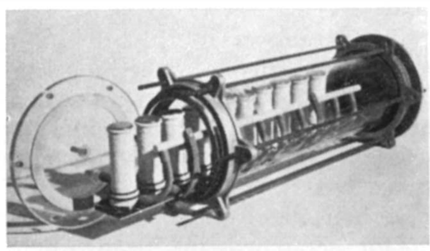
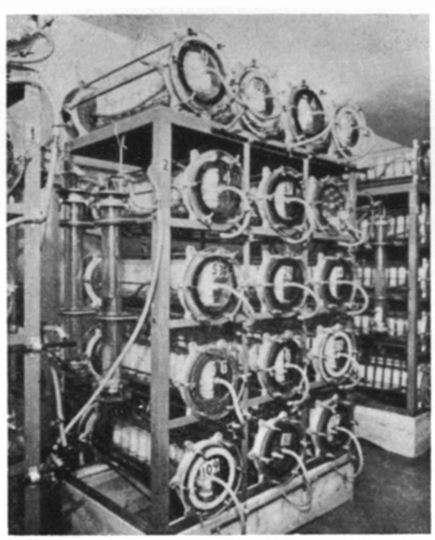


Figure 5. Pressure Chamber and Manifold Courtesy, Fisons Fertilizers Ltd. (10)

connections are provided at the front of the cylinder, one for introducing compressed air and the other for connecting the manifold to the atmosphere.

Present facilities for these tests (Figure 6) at Fisons Levington Research Station in England consist of 112 chambers, which enables tests on 224 samples in replicates of 5 to be carried out at a given time. Storage of the samples in the pressure chambers may range from 1 week to 6 months.

Figure 6. Arrangement of Pressure Chambers in Frame Courtesy, Fissons Fertilizers Ltd., (10).



The ratio of length to diameter of the fertilizer cake is 2:1. The crushing-strength test of the cake is applied without removing the Neoprene sleeve. The crushing-strength values of 5 replicates are reported to be within ± 13 per-cent of the mean value. Fertilizer is considered to possess free-flowing characteristics if the crushing strength after 6 months at 35° C. and 6 p.s.i. does not exceed 10 p.s.i.

The tests will furnish an impressive backlog of experience and data that should prove invaluable in the production of free flowing fertilizer. This comprehensive work serves to indicate the vast importance that the fertilizer industry places on the physical condition of its products.

Summary

Conditioning of mixed fertilizers for the purpose of decreasing their caking tendencies is a continuing problem of the fertilizer industry owing to the wide range of physical and chemical conditions under which fertilizers are made, stored, and transported.

The alleviation of caking is discussed with respect to formulation and processing techniques, particle size and density of coating agents, and the use of some relatively new types of conditioners, such as fatty-amine chemicals, resins, waxes, and oils. Recent developments in the laboratory technique for determining the caking tendency of fertilizer are reviewed.

Conditioning agents become of practical value in the production of free flowing fertilizers only after suitable formulation and processing techniques have been used to prevent severe caking of the product.

Acknowledgment

Grateful acknowledgement is made to R. J. Nunn (*10*), Fisons Fertilizers Limited, United Kingdom, for permission to reproduce Figures 4, 5, and 6.

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Illustrations

MODERATOR REYNOLDS: Thank you very much, Mr. Hardesty.

We have time for some questions. Who will be the first?

While you're thinking of some questions here, I believe Mr. Hardesty does have a question. We referred earlier to the questionnaire and you are all familiar with it, which we sent out last spring. We did receive approximately 175 replies. One of those happened to have been directed to Mr. Hardesty and he will answer that at this time.

MR. JOHN HARDESTY: I received this question from the Committee as follows:

"What are the controlling factors of XOX grades while producing to prevent pile set and also bag set, primarily 14-0-14 and 20-0-20?"

The answer to this question must necessarily be something like that which the fellow got when he went to the medical center to see what was wrong with him and they gave him a good diagnostic examination, came back and the doctor scratched his head for a long time and finally he said, "Have you ever had this before?" The fellow said, "I sure have." The doctor said, "Well, I'm sorry to inform you, you have it again."

(Laughter.)

The next logical medical question would be: how much do I owe you? In medical terms it would be $365.00.

My directive on this question says to answer it in a hurry, a very short answer, please. The shortest answer that I could give would be to say that there is no controlling factor during production that will prevent pile set and bag set because normal set in a fertilizer is not unusual and does not do any particular damage.

Mr. Chairman, I don't want to leave it that way. These mixtures are severe cakers and I assume that is what the questioner meant when he said bag set. Some 80,000 tons of 14-0-14 and 15-0-15 are produced annually in the U.S. and it is usually entirely satisfactory in condition. The slurry granulation process is used and the controlling factors of this process are temperature, density and pH of the slurry along with the mechanical details of the process.

A slurry of ammonium nitrate, KCl and dolomite is dried at the surface of undersized product granules until the successive dried coatings have built the product up to a size that will pass over the product screen, and I believe that that will be discussed by Ben Smith later this afternoon; that is, one of those processes will be.

Basic retention time in the process, to allow chemical reactions to occur in drying and cooling are also very important. That's as much as I can help with 40-0-14 and 20-0-20. There is not sufficient room in the granule for adequate dolomite to cushion the effect of these highly soluble salts. While some 12,000 tons of it are produced annually, it is subject to severe caking and I know of no economical way to get around it.

As far as physical condition is concerned, it seems to me that there is a ceiling on high analysis, there is a limit as to how far we can go with the amount of highly soluble, hygroscopic salts in the mixture.

MODERATOR REYNOLDS: Thank you very much, Mr. Hardesty.

Does anyone have any questions?

MR. WILLIAM NEWSOM JR. (International Mineral Chemical Corporation): I have a question for Mr. Phillips. I would like to know his opinion of the proper procedure under which an ammoniator-granulator should be operable?

MR. A. B. PHILLIPS (TVA): Bill, I think that we woud say 30 per cent of the critical speed for one that has a sparger under the bed or 35 if you get by with it. This work on feed that was done by A. T. Brook, Fisons, Limited, Developments in granulation techniques, Fertilizer Society, London. Proceedings #47, November 27, 1957, indicated that for a drum without a sparger in it, 50 per cent of the critical speed was about optimum. But with spargers in the drum, it would be very difficult to reach that speed because of the drag caused by the spargers.

A drum that had a very rugged mechanism could run higher than, say, 30 per cent of the critical speed, but probably not many of the continuous ammoniators are rugged enough to go up much higher than that.

MODERATOR REYNOLDS: I saw another hand back there for a question.

A MEMBER: I'd like to address this to Mr. Hardesty. On the average particle size of conditioners, is that determined on the basis of surface area or on the basis of the distribution curve of those conditioners?

MR. HARDESTY: I think you could base it on the distribution curve; that is, for instance, if you are starting out — if I understand you correctly, you start out with a 97 per cent on 20 microns, and 65 per cent on 10 microns and so forth on down the line; I think it could be based on, we'd better say, the weighted average of the percentages of those materials present. I think that that would be logical to assume.

SAME MEMBER: I would like to ask Mr. Hardesty, on these bombs, are they putting air pressure on there or putting on the weight, or can you say why they use that?

MR. HARDESTY: I believe the improvement that they claim is that you have the pressure distributed from granule to granule within this neoprene sleeve, the same as you do in a bag of fertilizer when you are stacking them and have pressure on the bottom bags. I think that's the idea behind it, and then it gets away from any stress or pressure at the surface of a cylinder like this.

I believe it is an improvement. I think it is an improvement over the old method of just putting the sample in a bomb and then putting hydraulic pressure on it or mechanical pressure on it.

SAME MEMBER: Along the same line, I would like to ask Mr. Hardesty, what strength do you use after application?

MR. HARDESTY: I guess they use air pressure, but either air pressure or hydraulic pressure, as long as you have an accurate instrument that will give you the pressure at which the cake breaks is perfectly satisfactory.

MODERATOR REYNOLDS: Would the persons asking the questions go to the mike? I believe the members can't hear and also we do need identification for the record.

Any more questions?

As you can recognize, I think the question and answer session is really one of the backbones of our group. I think one of our members used to refer to it as doing a little "fussin". That's what we'd like to have.

There's one question in my mind for Mr. Hardesty.

We were discussing the addition of conditioners. Has there been any recent work performed concerning how effective the conditioners are when they are added as the product is manufactured, or say within a few days or say at the time of shipment?

MR. HARDESTY: I didn't get that.

MODERATOR REYNOLDS: In other words, if, for example, you add your conditioner to the particles as they go off the belt into storage, is there any difference between the degree of caking or conditioning efficiency you get there as compared to adding the conditioner at the time of shipment after storage?

MR. HARDESTY: I think several people have found that if you add the conditioner just before it is shipped that you get some better results with conditioning. I think it all depends upon the fertilizer. If you have a fertilizer that is fairly damp at the surface and you are trying to condition it with a powder and you throw the powder in and it all lands on one place, of course, you are going to have some of it fairly well conditioned and the rest of it isn't conditioned at all, and if that goes on, it can give you some serious trouble. Whereas, if the fertilizer is fairly dry and the conditioner gets scattered through the mass, then you get some fairly good conditioning and it's more apt to be in that sort of condition just before you ship than it is before it goes into the storage pile.

MODERATOR REYNOLDS: Ralph.

MR. RALPH W. HUGHES (Farm Bureau Cooperative Association, Columbus, O.): What of the temperature factor in the building?

MR. HARDESTY: It is not too great inasmuch as it affects the moisture of the surface particles. You've got a cooling particle and it has a tendency to pick up moisture during its cooling, why, then the temperature indirectly affects it, I think, but I think it's a moisture proposition because it's the particle that determines how much conditioner is picked up.

Of course, we know that temperature affects caking a great deal in the storage pile. I don't think that's what you referred to. As your bags in the storage pile cool down you get considerable caking.

Does that answer your question?

MR. HUGHES: Yes, sir.

MODERATOR REYNOLDS: We have time for about one more question.

MR. JOHN S. DENNIS (United Clay Mines Corporation, Trenton, N. J.): I have one other question on this, Mr. Hardesty. Do you feel a conditioner with an affinity for the granule is a desirable approach rather than a conditioner which has an affinity for its own base materials?

MR. HARDESTY: A conditioner, that is something on the conditioner to make it stick to the fertilizer. Is that what you mean?

MR. DENNIS: Yes.

MR. HARDESTY: Of course, there you are up against the same problem of what kind of condition is your fertilizer in, in the first place? You can make fertilizer so that you don't need anything to make a conditioner stick to it; it sticks to it too fast, too much. As I said a while ago, you can get a fertilizer that's damp enough after it is produced to soak up all of your conditioning powder and then you have part of it coated and the rest of it isn't coated. It is the same way with these materials which you put on the powder to make it stick. If you have just the right conditions it will make it stick, yes.

MODERATOR REYNOLDS: I saw another person up over here.

MR. JOHN W. PACKIE, Chemical Advisor (Standard Oil Company, N. J.): I have another question for Mr. Hardesty. Has any work been done on an accelerated test to perform strength tests in a shorter time and get some type of correlation with the actual long term pressure stability of the material?

MR. HARDESTY: Yes, Dr. Nunn in his paper says that they can correlate these tests with bag storage tests very well, and we have done some of that in our laboratory in the past and you can develop a way of getting good correlation, but one thing there is that you have to have a man working with it all the time. If you have different people working on the caking process, you're liable to go way off the beam and I think we could do a lot more corroborative work in making these tests to see just how accurate they are.

Dr. Nunn claims that he has accuracy within plus or minus 13 per cent. I believe in a paper some years back we claimed that we had an accuracy of plus or minus 10 per cent. I don't know just how those two things would stack up if you put them along side by side. I think that this paper of Dr. Nunn's will give a greater accuracy than just putting the material in a caking bomb and putting pressure on it.

Did that answer your question?

MR. PACKIE: I was a little bit concerned about the long time, six months. I'm speaking of accelerated tests where you might test under certain conditions for, say, a period of one week.

MR. HARDESTY: Our past experience has been that one week has been long enough to give you a good cake that can be replicated, can be reproduced; one week under pressure at a given temperature will give you a cake that can be reproduced time after time and give you very good indications.

I think this method of Dr. Nunn's can be brought down to that. They have made these six month tests and this is what they get. I think that if they do it for a week, they'll find out that they can correlate them there, too, because if you can correlate them at one place, you certainly can do it at another.

MODERATOR REYNOLDS: I think we'll move along to our next subject. We really appreciate the fine papers that these two gentlemen, Mr. Phillips and Mr. Hardesty, have given us. We really appreciate your helping us out on these two subjects. Applaus:

Will the speakers on the Standardization Panel come forward.

At the 1960 Round Table Program we had a very lively discussion here on the problems relating to non-uniformity of raw materials. This, as you recall, was one of the highlights of that particular meeting. It is not the intent of the Round Table to promote standardization of raw materials or products; our purpose is to exchange ideas and information and be of service primarily to our industry. However, from the discussion of last year, the magnitude of the mutual problem of non-uniformity is quite apparent.

This year we hope to bring you a progress report. We realize that work has been accomplished during the past 12 months, and even prior to that. We wanted to gather four people here whom we believe can do a very good job in bringing us up to date on what has transpired since last year's meeting.

We will call on these persons individually, and will hold off on the questioning until we finish with the fourth person.

We have broken down this subject between Nitrogen, Phosphates, Potash and The Users' Panel Representatives. The first person, who will speak on the subject of Nitrogen in standardization and uniformity, will be Mr. John C. Frederick, Tech. Service Representative, Sohio Chemical Company, Lima, Ohio.

Standardization and Uniformity of Nitrogen Solutions

J. C. Frederick and S. Grant

Since the subject of this portion of the Round Table program is uniformity and standardization of nitrogen solutions from the producers viewpoint, it might be in order to first trace some of the progress that has been made as far as uniformity and standardization is concerned. Then, later we will present some thoughts for your consideration as to further standardization which might be desirable. This new area for consideration has to do with the so called "salt out points" of solutions. Before discussing this "salting out" topic let us first review the progress that has been made in uniformity.

Standardization of Nomenclature

Prior to 1958 various systems were used to designate the ammoniating solutions used by the mixed fertilizer industry. At this time there were approximately 50 solutions listed as being available to the fertilizer trade in addition to anhydrous and aqua ammonia of various concentrations. There were almost as many systems for naming these solutions as there were nitrogen producers. Table Number 1 will show a popular ammoniating solution having a 44.0% nitrogen content, and the various names given this same solution back around 1957.

Table 1

A-6.4 G IA AM IX 2M 44 2XI 144

The symbols on this table all indicate the same solution having a 44.0% nitrogen content.

The above nomenclature is certainly confusing to say the least. Even if every producer were calling the above solution, let us say Solution Z, the chemical composition of that solution would not be clear. Various combinations of ammonia, ammonium nitrate and urea are possible and still the total nitrogen content of 44.0% maintained.

In 1958 the mixed fertilizer industry and the nitrogen producers working through the National Plant Food Institute adopted a coding system that the majority of nitrogen producers followed. The system adopted at that time is as follows:

Table 2

Brand Name

440 (24 – 70 – 0)
N (NH3–A.N.–Urea)

The percentages in the bracket are rounded off to the nearest whole number and are always in the order indicated. The decimal point is dropped in the total nitrogen and the above 44.0% nitrogen solution becomes 440.

To illustrate how the above nomenclature avoids confusion, let us look at another 44.0% nitrogen with a different composition.

Table 3

Brand Name 440 (22-66-6)

Here the total nitrogen is again 44.0% but the ammonia and ammonium nitrate content are different than before. In addition, urea has been added. At a glance one can see that the total nitrogen is 44.0%, the ammonia content is 22%, ammonium nitrate 66% and urea 6%. The water content of course would be 100 minus the total of the three ingredients, or 6%.

Standardization of Analytical Procedures

Other progress has been made in standardization of analytical procedures for materials and complete mix goods. A committee organized under the auspices of the National Plant Food Institute was instrumental in developing and Publishing a manual of standard analytical procedures for the industry. So you see some progress has been made in the uniformity and standardization of nitrogen solutions.

Standardization of Physical Properties of Solutions

As a further step in this direction quite possibly the physical properties of the nitrogen solutions should be considered. The specific gravity and vapor pressure are certainly uniform in that all producers by and large use the same methods to establish and terms to designate these properties.

Most producers show the vapor pressure at 104° F., while some show the vapor pressure at lower temperatures. This 104° F., was chosen in order to provide a margin of safety to the consumer for the planning and design of his facilities for handling various solutions. The 104° F. is certainly safe since most solutions are loaded at temperatures well below this figure. Quite possibly as a further help to the mixed fertilizer industry, the temperature where a particular solution has O psig vapor pressure might also be indicated.

As mentioned in our opening remarks, there is certainly one other area where standardization should be considered. This other area being the so called "salt out" temperature of nitrogen solutions. Other terms are given to his property by various nitrogen producers. The most popular names used are as follows:

Table 4

Freezing Point
Salting Out Temperature
Crystallization Temperature
Saturation Temperature

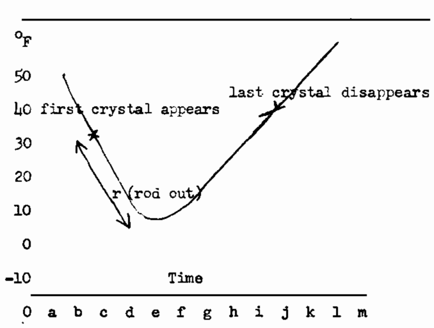
Quite possibly there are other terms used to designate this same property by some producers. What may be more confusing to the mixed fertilizer industry than these four designations, is just what these four terms indicate.

There is no official established established method for the determination of this property, be it called salt out point, saturation point, icing point, or what have you.

One plant superintendent I know of calls it the "rod out" point. Meaning that if the solution temperature gets below this point, there is the possibility he may have to "rod out" the supply lines from his storage tank to his ammoniator.

On the next table we will attempt to show the phenomena produced when an ammoniating solution is cooled. Let us assume a hypothetical ammoniation solution which is completely soluble at 50° F. Then we cool that solution at a predetermined rate.

Table 5



On the above table shown, the X is where the first crystal was visually observed. As the solution is further cooled, more salts drop out of solution until eventually the mass is solid. This solid point (r), or rod out point varies from solution to solution depending on the chemical composition of that solution, rate of cooling, vibrations, impurities, and so forth.

If the cooling medium is removed and the solution is allowed to warm back up, the salts slowly go back into solution until at point (Y) the last crystal disappears. This last point (Y) is always higher than point (x) and is the point above which no crystals are present. This is the lowest absolutely safe temperature at which no crystals will form.

The point (X) is a measure of the degree of supersaturation that this particular solution exhibits. The degree of supersaturation will vary with solutions, rate of cooling and other factors in the laboratory or plant. In storage tanks or in supply lines, small amounts of impurities might act as a seeding agent and reduce the degree of supersaturation.

In order to handle these solutions with any degree of certainty you must know what is meant by the varying terms used by the different nitrogen producers and what is denoted by these terms. As an example let us look at a 440 (22-66-6) nitrogen solution, and the reported temperatures from various producers.

Table 6

Company A	12° F.
Company B	14° F.
Company C	5° F.
Company D	−17° F.
Company F	19° F.
Company G	8° F.

As you can note, this same solution has a reported range of −17° F. to +19° F., or a 36° F. spread. Also, various terms are used to denote these temperatures. These points will vary on the cooling curve previously shown depending on the laboratory procedures used, or the exact significance of the point.

If the laboratory procedures to determine this physical property were standardized then you the consumer would certainly be able to plan your solutions handling with a greater degree of assurance that the "roding out" point would not be reached. A common term to denote this property might also be in order.

You will note that at no point on the cooling curve previously discussed did I use the term "salting out," and this is by far the most commonly used term.

For the sake of uniformity we might all work together through some organization such as the Chemical Control Committee to arrive at a standard procedure for the "roding out" point and a standard term to describe this.

Phosphate Report

MODERATOR REYNOLDS: Thank you, John.

Our next speaker on this panel will discuss the subject of Phosphates, Mr. Edward F. Carnell of W. R. Grace & Company, Davison Division.

MR. CARNELL: Thank you, Joe. Members of the Round Table: To sum up last year's events in the P_2O_5 Section, after the users panel finished telling the producers some of the main points of concern in using raw materials of irregular composition. The raw materials panel tried to explain some of the whys and wherefores of raw material production and to give an indication of what is done now or what has been done to try to maintain as much uniformity as possible without putting the cost of your product so far out of reason that the additional controls would not be justified.

It has been interesting to note some of the remarks of the users who are also producing superphosphate compared to those who are not. Some of the mixed goods folks who make superphosphate in their own plants understand this problem of controlling natural variables in raw materials with a minimum of processing.

Also, last year we put together a tabulation of published information, specifications mostly from producer's data sheets. These data on which remarks were made by both the users and producers panel revealed that a wide variety of categories have been used for reporting specifications, some of which are actually meaningless and have been carried forward over the years just out of force of habit or accepted misuse.

Terms such as run-of-pile, moisture with no indication of the method used to determine it and screen size with no indication of the type of screen that was used.

The supplier's actions in following some of these suggestions or investigating them have — that is, those made at the Round Table last year—obviously and necessarily have been on an individual basis.

Some of the specific suggestions that have been made to date were under general suggestions: drop the term run-of-pile for the use of pulverized triple and single superphosphate. Another one that was not satisfactory last year was the speed with which shipper's analysis were forwarded to users. The recommendation on that was to try to get the analysis to the user within two days.

Under the heading of chemical it was to give the method of determination of moisture when moisture is given. To report free acid as H_3PO_4 and give the method used to determine it.

Under the heading of screen analysis: use Tyler screen size and report at least the 10, 20, 35, 65 and 100 mesh fractions.

A request for reporting uniformly.

In addition to these, suggestions have been made for control of the APA on run-of-pile to a 5 per cent, plus or minus, and to control particle size as follows: in standard grades, 5 per cent plus 10, 95 per cent plus 100, and both of those would have a tolerance of plus or minus 5 per cent. In granular, 10 per cent plus 6, 95 plus 20, each again with plus or minus 5 per cent tolerance. Coarse, 10 per cent plus 10, 95 per cent plus 35, with a plus or minus 5 per cent.

We think that all these suggestions for standardization, particularly for standardization of reporting, are valid and worth while. We feel we should give at least the information called for in these recommendations.

As for controlling the product with the chemical and screen tolerances suggested, I think our position is unchanged as we expressed it last year; we consider these levels good goals and I think probably the others will join me in saying this, that we will continue to strive to have 100 per cent of our products fall within them.

If any of the other suppliers of phosphates have any comments to add to this, I would appreciate it.

Thank you.
(Applause.)

Potash Report

MODERATOR REYNOLDS: Thank you, Ed.

Be thinking up your questions, because we are going to have a little time here after we get through with the next two speakers for questions.

The third member on this panel will discuss the subject relating to Potash is Dr. Ed Kapusta, Potash Company of America.

DR. E. C. KAPUSTA (Technical Sales Director, Potash Company of America): Thank you, Joe.

It is always a pleasure to appear on the program here. Last year at this meeting, as you know, representatives of the potash industry and our counterparts in the nitrogen and phosphate industries had the privilege of describing some of our products to you, also the privilege of discussing some of the problems associated with the manufacture and shipment of the raw materials which we supply. More importantly, we were afforded the opportunity of learning more about your plant problems as related to raw materials use and an opportunity of learning more about the types of raw materials which you felt were necessary for use, or best suited for use in your operations.

I am certain that my friends in the potash industry will agree with me in stating that this exchange of thoughts was very interesting, very informative and we hope mutually profitable.

The technology of mixed fertilizers involved rapid and complex changes in recent years. With these advances came production problems, problems shared in alike by both mixed fertilizer producers and their raw materials suppliers. Some, but certainly not all of these problems, have been related to some degree to the characteristics of the raw materials used.

In several instances needs developed for new or different types of raw materials.

Certainly I think the potash producers and the producers of other fertilizer raw materials have recognized and reacted to the changing needs of mixed fertilizer producers.

As has been indicated to you on numerous previous occasions, these suppliers are most anxious to provide you with the quantity and quality of products which you desire, working within the limitations of their production capabilities.

As noted at the Round Table session last year, it is technically possible to produce fertilizer materials of any desired degree of purity or particle size; however, it has not always proved to be economically feasible to make such products from the viewpoint of both the producer and the consumer.

Although a divergence of opinions has existed as to the types of raw materials deemed to be most desirable for specific processes, raw materials producers have moved toward more definite product goals based on the generally indicated product preferences expressed by most of you at the Round Table Meeting.

Last year's sessions of the Round Table proved to be most helpful in this respect.

Now regarding the fact that further improvements may be called for, we feel that considerable progress have been made by suppliers in their attempts to furnish the types of materials, products and services essential to optimum plant operation.

I would like to very briefly comment on some of the progress which has been made within the last year.

At the meeting last year it was pointed out that considerable confusion existed in potash product nomenclature, as a result of the variety of product names and trade designations used by potash producers. We believe that this problem has been largely resolved through the efforts of a Potash Industry Committee appointed by the National Plant Food Institute to establish a standard system of nomenclature for the muriate of potash products.

The recommendations of this group have been implemented and are well known to you. Muriate of potash products are now denoted as standard, coarse or granular, indicating the smallest, intermediate and largest particle size products.

Standardization of product nomenclature has eliminated much of the confusion which had existed in ordering and shipping of these products, and has worked to the advantage of both the supplier and the consumer.

As you know, earlier this year members of the users panel suggested ranges of particle sizes for solid raw materials. As Ed Carnell pointed out, essentially these suggested particle sizes call for a standard product between 10 and 100 mesh, a coarse product between 10 and 35 mesh, a granular product between 6 and 20 mesh. To the best of my knowledge the majority, if not all, of the domestic potash producers either now supply or are planning to supply products which fall within these suggested particle size ranges.

Considerable progress has been made and is being made to provide you with the types of materials which you want and need.

Product quality control in the potash industry has assumed a position of paramount importance with the imposition of these more stringent product specifications. However, as is the case with all human endeavor, individual shipments may occasionally arrive at your plant which may not measure up to your expectations. Should this happen, please let your supplier know. He is as anxious as you are to rectify these slipups. I feel certain that you haven't been too reticent in the past, to let us know, but please continue to do so.

Producers have made considerable capital investments in improved handling and spinning equipment, and other facets of inplant chemical control, in an attempt to eliminate or reduce day to day variations in product quality; shipments of a given product for an individual producer will in most cases show only modest variations in analysis.

One of the speakers at our 1960 Round Table estimated that part-of-pile variation in potash analysis from the particular plant were in the order of about two tenths of a percent K_2O from the average of several years production. Now, of course, somewhat larger variations may exist between products supplied by different producers, depending on the method of production employed, the grade and type of ore processed and a host of other variables.

These variations are quite typical of those that you encounter in the mineral extraction industries.

Prompt and complete knowledge of the chemical analysis of individual shipments of potash and other raw materials is, of course, essential to proper mixed fertilizer formulation and process control.

Raw material suppliers are aware of the necessity for this information and make every effort to provide it as rapidly as possible.

Shipping notices listing chemical analysis and other related information are generally in the hands of the customer well in advance of the arrival of the car of material. In some cases, there is a possibility that this information may not be promptly relayed to the proper production staff member.

Now, I assume that these situations, where they exist, can be easily remedied by working within your company.

In conclusion, production and shipment of desired types of products of uniform and consistent quality is the desire and goal of all raw material suppliers. Considerable progress has been made toward this end as illustrated by some of the examples which I have cited. It is my personal belief that standardization of raw materials may not be economically feasible nor even desirable in many cases from the point of view of the supplier or the consumer.

In our competitive society, suppliers of fertilizer raw materials, as well as other segments of our business community, vie for the favor of the customer. Progress results from this competition. All other things being equal, the supplier who is able to supply consistently the type of product desired by the customer will undoubtedly be rewarded for his efforts. Product improvements result from this competition to the benefit of both the supplier and user.

Thank you.

(Applause.)

MODERATOR REYNOLDS: Thank you, Ed.

Our next speaker on this panel will be from the Users Group, Mr. Rodger C. Smith, Head, Fertilizer Research, Eastern States Farmers Exchange.

Progress With Uniformity of Ingredients — Users' Viewpoint

Rodger C. Smith

THE Executive Committee of the Fertilizer Industry Round Table has asked for a progress report on uniformity of ingredients since our meeting a year ago. Speaking generally, I believe that if is fair to state that progress has been made on this matter. Further, I am certain that I reflect accurately the attitude of the users of fertilizer ingredients in expressing appreciation to those individuals, representative groups, and manufacturers who have contributed toward this progress. Through the auspicies of the Round Table a very involved, complex problem has been constructively approached. It had become complex because of the rapid development of both the manufacture of ingredients and the utilization of those ingredients. The time lag between market survey and the manufacture of an ingredient of certain specifications has proved to be excessive in view of the rapid changes.

As review of the problem, let me quote from my remarks made last year — "Our message today is not so much to indicate product types; uniformity within certain classifications is perhaps even more important than the specific types — we need more continuity of control — there is a gap between the apparent technical developments in the fertilizer industry and the record of the industry as indicated by the analyses of individual manufacturers — our need today is specifications, uniformity within tolerances, information and analyses and methods, uniform or similar terminology."

Now some quotations from the statements last year of other members of the Users' panel — "Run of pile triple produced today needs to be improved. Screen tests on a recent car showed that 60% passed through a 35 mesh screen. In addition, standardization of triple specifications between producers is lacking . Summarized screen alalyses of three triple cars received recently are as follows: 13-39% between 6 and 16 Mesh and 54-78% through a 20 Mesh screen. We had actual cases where from day to day deliveries ran as high as 2.67 difference—on the potash, the difference is not too bad, but nevertheless we have to stay on the low side to protect ourselves—when I make a 5-20-20 and sell it, if I put more than 5-20-20 in it, you know who pays for it; if I put less than 5-20-20 in it some guy taps me on the shoulder and it winds up the same guy is doing the paying again."

Still quoting from the remarks of the users' panel last year, "I think it is time for us, and particularly you who are producers of prime supplies for this industry, to sit down and hold a constitutional convention, if you will, and come up with some sort of rules of the road by which you as an industry can live and from this tell us standards that we as consumers of your materials can expect to be adhered to when we buy your products."

Gentlemen, this is not a constitutional convention, but we are coping with an important problem in a very democratic way. Through the aid of this forum, improved communications is causing better understanding of what is needed and what can be reasonably supplied.

In this regard let me repeat from my summary statement last year. "I think it is clear from these remarks and from our knowledge of the various processes of mixed fertilizer manufacture that uniformity of ingredients is even more important than the exact product specifications." Stated another way, users of ingredients can adjust satisfactorily to a limited number of forms of each ingredient provided there is reasonably uniform particle size and each form has other satisfactory characteristics.

An attempt was made by members of the users' panel since the 1960 meeting to determine the minimum needs of the industry as to particle size and uniformity of solid ingredients. In doing so, an effort was made to recognize the different processes of ingredient use, the rates of production with given equipment, and other considerations. There developed from this discussion what we believe to be a reasonable suggestion and one that permits the ingredient manufacturer considerable latitude to cope with differences in raw materials or processes used. A relatively normal distribution curve is assumed, however, within the indicated limits. This suggested particle size is as follows:

Suggested Particle Size — Tyler Mesh — Cum. % on*

	6	10	20	35	65	100
Opening—in.	.131	.065	.0328	.0164	.0082	.0058
Standard		5			85	95
		(0-10)			(80-90)	(90-100)
Coarse		10		95		
		(5-15)		(90-100)		
Granular	10		95			
	(5-15)		(90-100)			

*Tolerance of plus or mnus 5%.

You will note that only two screen sizes are mentioned for "coarse" and "granular" and three for the "standard" grade. Also, that a tolerance of $\pm$ 5% is suggested.

It is noteworthy that the suggested particle size for the "standard" grade is similar to that concluded for triple superphosphate in a very useful paper entitled, "The Effect of Particle Size on the Granulation of Triple Superphosphate," by Boyce M. Olive and John O. Hardesty of U.S.D.A., Beltsville, Maryland, presented at the American Chemical Society meetings at Chicago in September.

Progress has very definitely been made during the past year toward achieving the goal as expressed in this table. Muriate of Potash products are now designated "standard," "coarse" and "granular." Very definite, almost spectacular, progress has been made toward uniformity and improved particle size of Muriate of Potash. This is commendable.

Triple superphosphate was singled out in the remarks last year as being the worst offender in terms of variation in chemical analysis and excess fines. Members of the panel report some improvement in variation of chemical analysis. They report also some activity toward reduction of the fine fractions. It is recognized that triple superphosphate is manufactured using a variable raw material and control problems are substantial. Realizing the resources of technical manpower and facilities of each triple superphosphate producer, it is not surprising that users expect further progress toward uniformity and that reduction of the finer fraction can be achieved. I predict that progress will be made toward these ends and, further, that a reasonable balance between increased costs incurred and increased value to the customer — the mixed fertilizer manufacturer — will occur.

"Run of pile" normal superphosphate shows little evidence of being anything but what the term "run of pile" denotes. This is not to say but what there are some excellent sources of normal or 20% superphosphate. This product is a large volume one made from a product of nature — although processed — and sulfuric acid usually a spent grade. The processes used vary somewhat also. Cost is low. It is well to take note however, that other forms of phosphate are now growing in use more rapidly than normal superphosphate. If this trend is to be slowed, normal superphosphate must approach more nearly the classification, "standard."

Sulfate of Ammonia, similar to normal superphosphate, varies greatly in particle size within and between manufacturers. Substantial effort is being made by many of the manufacturers to improve the product. Analyses are very uniform and physical condition is generally improved.

This brief progress report attempts to reflect the concensus of opinion among the users of ingredients. There is considerable evidence of progress and indication of study being made toward further improvement. Manufacturers of ingredients can be assured that their recognition of the problem and making reasonable effort to meet it is appreciated by the mixed fertilizer industry and other users of ingredients. It is commendable.

The registering of a complaint by those of us who are users followed by suggestion of changes and the subsequent recognition and action by ingredient manufacturers conveys a responsibility to us. That responsibility is to give whatever study necessary to adjusting our processes to the use of "standard," "coarse" and "granular" solid ingredients. During the past decade opinions of physical characteristics have varied widely which has led to the variation in products offered. These opinions now have been classified into three classifications. Research information with respect to segregation of ingredients in various types of mixed fertilizer or blends has been considered. Provision for reduction of dustiness is made.

We users have a responsibility to make workable this classification of ingredients. I am certain that we can with very minor adjustments, if any, use very satisfactorily one or more of these three types. The only exception that I can visualize is possible that the few slurry process plants may want a finer Muriate of Potash. We have everything to gain and nothing to lose by giving every possible encouragement to this important development.

MODERATOR REYNOLDS: Thank you very much, Rodger.

I think you all will agree with me that these fellows have done an awful lot of work and an awful lot of searching to try to gather opinions and thoughts from our industry.

I think as far as going back to the theme of last year on standardization and uniformity, we brought out many, many ideas. I think that we have also tried to refrain from establishing standards ourselves as a group, because that is not our purpose. The thing we want to do is to discuss these points and our problems, bring these out to the people who are users, to think about them, to the people who are suppliers, they go back and do the best they can along the opinions that have been expressed. I think that is what has happened here. I think many of the ideas which were expressed openly last year fell on the ears of people who took them back and did something about them.

I think we are accomplishing what will be good for the industry here without getting into setting standards and trying to get into some kind of regulations.

Let's have some questions for our group.

MR. SPILLMAN: I'd like to ask the Potash boys if it is possible to get screen tests on each shipment of potash? Screen tests are very helpful to us, and we can take each shipment, if we have a screen test, and know just about what to do with our formulas. This is a very important item from our standpoint.

MR. KAPUSTA: Al, of course, I can't speak for the other potash producers. I will say this, as far as our company is concerned, samples are analyzed, screen analyses are available on request. We have not sent them out as a matter of course.

I do want to make one other comment here, and then I would welcome the comments of any of the other producers in the room.

I think we — of course, I am

prejudiced now — I think we do a marvelous job in controlling plant production. I think you can take the typical screen analyses which are listed and use them with a fair degree of confidence. Now, I'm not going to say they're going to be 100 per cent perfect; we make mistakes, we slip up too. But I would suggest if you want that type of information make it known to your suppliers and I think they'll make every effort to get it to you.

MODERATOR REYNOLDS: Any other comments, observations?

MR. WAYNE W. KING (W. S. Tyler Co.): Joe, I'd like to augment or supplement what has been said. Within the limits of my ability, I will mail each and every one of you a new handbook released in September. It will be released today but it was released by ASTM, Bureau of Standards and International Sieve Committee, Handbook No. 53. You will note it is pea green and I'll mail every one of you one. You can have as many as you want if you will let me know.

MODERATOR REYNOLDS: Thank you, Wayne.

Any other questions, comments? Mr. Hignett?

MR. TRAVIS P. HIGNETT (Chief Applied Research, TVA): I'd like to raise the question of the uniformity of reporting bulk density. Last year various bulk densities that were reported in some cases did not state whether the densities were packed or vibrated or filled without any vibration. It is quite possible to get variations of as much as 20 per cent in bulk density by different methods or procedures of measuring.

I would like to ask the panel, therefore, whether they have considered whether some uniformity in procedure for determining and reporting bulk density is desirable, and when these materials are used in the bulk blends the density may be of importance, but in that case shouldn't the density that we want be the apparent specific gravity rather than the bulk density?

MODERATOR REYNOLDS: The problem relates to methods for determining bulk density in relation to loose, packed, vibrated or some other system.

Mr. Carnell, would you care to comment?

MR. CARNELL: I think this would be a real good one to take under advisement.

(Laughter.)

MODERATOR REYNOLDS: That's an easy way out.

MR. CARNELL: I think it really is a problem to all of us and I think my first experience in it was trying to make inventories come out in the plants and I found that how you classed your densities depended on how much inventory you had.

(Laughter.)

But I think you ought to set up two or three people to investigate it and make some recommendations on it.

MODERATOR REYNOLDS: Ed.

MR. EDWARD KAPUSTA: Actually, I think the point is well taken. I am quite familiar with the method of reporting bulk density for use at two potash companies. We do report the so-called loosely packed or just filled and then tightly packed and, if there is variation, to my knowledge I don't know of any efforts that have been made to standardize the method used.

I think, Travis, the point of using apparent specific gravity would be something that should be looked into.

MODERATOR REYNOLDS: Rodger, would you care to comment?

MR. RODGER SMITH: I think the question is an appropriate one but I can't add anything more.

MODERATOR REYNOLDS: Perhaps maybe we can get a report back on that one at next year's meeting.

MR. WILLIAM HARWOOD (International Minerals and Chemical Corporation): For the benefit of those who may not know it, Fairbanks Morse now makes a small grain tester which is normally used in the feed industry for measuring pounds per bushel.

They are also, on special request, making this same gadget calibrated in pounds per cubic foot, and we have used them for several years with considerable reliability. We have checked it against cubic foot boxes. We have used it in year end inventories and so on and it is quite accurate and very easy to use. You carry it right into your plant and into your field, or rather into your storage area, and it is quite accurate and very easy to use.

MODERATOR REYNOLDS: Any other questions, comments?

I think we are all agreed that we are much closer to what we are striving for concerning this problem of uniformity. I think further work needs to be done on an individual basis once we have digested some of the information that has been compiled here. I can assure you that this group did considerable work and effort to try to get a cross-section of opinion from industry. I think they have done an excellent job.

Unless there are any other questions, we will dismiss this panel and proceed on with the next one.

Thank you very much.

(Applause.)

At last year's meeting we had a speaker who described a nitric phosphate process which utilized a piece of equipment referred to as a Spherodizer. This year we are fortunate to have with us a person who is going to speak on the subject of The Spherodizer, to elaborate on it a little more fully and to bring us up to date on that subject.

Mr. Ben G. Smith, Director of Development, Chemical & Industrial Corporation, Cincinnati, O., will speak to us at this time.

Application of Spherodizer to Granulation

B. G. Smith

MR. Chairman, members of the Round Table: On your program you have listed that I will give a talk describing the application of the spherodizer process to granulation. I will modify that a bit and try to describe to you the spherodizer process hoping you will see, as we believe, that spherodizing is not a modification of granulation or is not basically similar to the procedures that are now performed to pelletize fertilizer materials.

From a historical point of view, we developed the spherodize process to pelletize a slurry, a liquid, a magma or a pulp. Previously most development work had run to pelletize solids, or mixtures of solids, or mixtures of solids and liquids, with handling of flow qualities similar to solids, into granules. In essence their problem was to convert this by addition of heat or moisture into a plastic state and thence to pellets.

Our problem, however, was to convert a slurry into pelleted form. This had also been done and is done now in the ammonium phosphate industry by adding additional solid product back to the slurry raw feed to such an extent that the whole mixture is at or about the granulating point and hence granulating by procedures that were similar to those normally used to pelletize solids. Though these procedures are efficient in the pelletizing of solids because of the high solids to liquids weights used, they are inefficient for slurry feeds for this very reason.

Our attempt was different. We attempted to get rid of the extra moisture of the slurry feed and then to pellet it. Drying of the slurry to a substantially dry solid had to be done without going through a mud state to avoid handling problems, caking and to maintain good heat and material transfer. We envisioned for this first step a conventional rotary dryer with a retained load of solid particles that were to act as the surfaces on which the slurry feed was dried. The solid effluent from this pre-dryer was then to be granulated in the conventional fashion.

We thought about the procedure a little further and realized, if the solid particles in the unit act as a large drying surface that we need, it is also quite possible that the slurry will stick on it, and we will have thus a buildup in size, which could be detrimental to the process or could be a new pelleting procedure.

We tested this in pilot plant and found that it did stick, forming hard rounded pellets of better than commercial dryness. We could, in fact, get materials of the order of tenths of per cent of moisture.

We further found that in this procedure the size of the drying unit was considerably smaller than would be a normal dryer to do the same job.

We thence decided to delete the subsequent granulating process, and rename the pre-dryer "Spherodizer." We have further elaborated on this technique and call it the "spherodize process."

I will now draw a short sketch of the process on the board (going to blackboard).

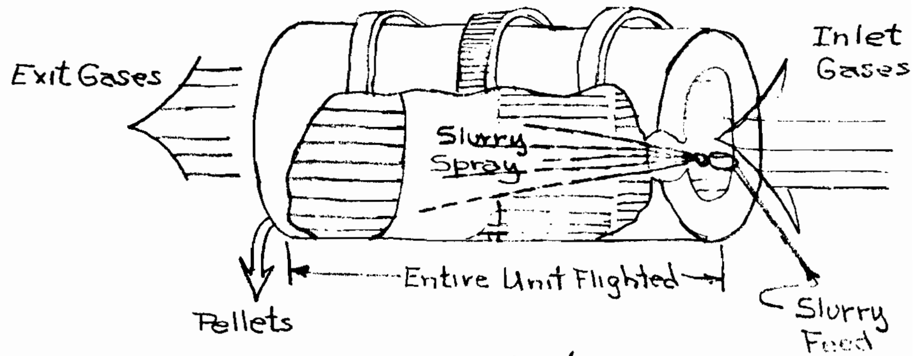


Fig 1
SPHERODIZER SCHEMATIC

I am going to try a shouting procedure because I would like to work in closely with the board, here.

In the spherodize process, as was stated before, the unit we call the spherodizer does both the drying and the pelleting. It is a unit very similiar to a rotary dryer in which heat is blown through, the feed as a solution or slurry is sprayed in. The rotating drum has retaining rings, is essentially horizontal and made so that it retains a large amount of material. Through the action of internal lifting flights, this solid material showers through the hot gases blown through, effecting thereby heat transfer from the gas to the solid particles involved. The atomized slurry contacts these particles which furnish the drying surfaces for the pelleting.

The simultaneous pelleting and drying within the spherodizer can be described with reference to Fig. 2. This shows one of the many "in-process" particles retained in the spherodizer and showered through the hot drying gases by the action of the lifting flights and rotation of the drum. During substantially all of these showerings, it and its fellows are enveloped in hot gases and during many of the showerings it is enveloped by a thin coating of slurry, sprayed in. The thin slurry coat dries to a solid envelope enlarging the particle. This dried and coated particle will receive many additional coats before emerging from the spherodizer as a product size pellet.

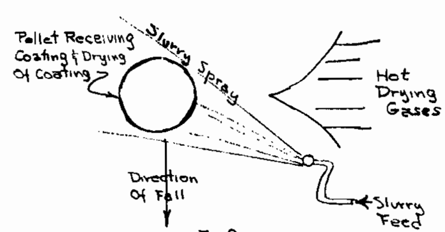


Fig 2
ACTION ON TYPICAL PELLET IN SPHERODIZER

The drying process is one that is entirely on the outside of the particle; it is a process of flash drying and is extremely rapid. The moisture level in the bed is always very low, usually less than one and a half percent, and very close to the final product moisture.

To further compare spherodizing with standard procedures of granulation, I will draw a moisture-temperature relation for, say, a particular formulation of 11-48-0.

In Figure 3 we draw the temperature as abscissa and the moisture or water content as ordinate. This graph shows the rheology or handling of flow characteristics of the material with changing moistures and temperature. It will be seen that its flow character falls into three types consisting of two

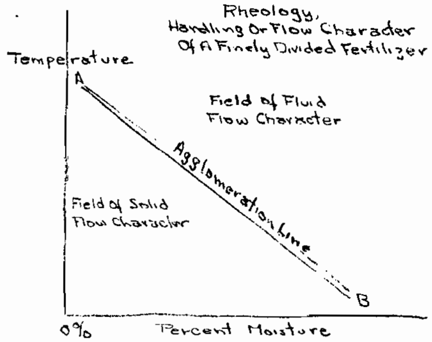


Figure 3

broad fields and a narrow band (line A-B on the graph). The field below and to the left of line A-B is characterized by material flow of a finely divided solid, as falling down a chute. Flow requires a large slope and is accomplished by proliferation of shear planes through the mass with the particles substantially flowing as individuals. The flow character of the field above and to the right of the line A-B is that of a liquid requiring relative little slope and flowing as a virtually adhesive mass. The line A-B defines the discontinuous transition between solid rheology and fluid rheology. It is the region of agglomeration where the mass shows discontinuous plasticity. It should be noted that line A-B has appreciable though slight breath.

Most of the granulating procedures, in fact, virtually all, operate at a point adjacent or in line A-B. They may use agglomerative mechanisms, that is, the drawing together of existing particles by cementation by the liquid phase or they may also coat, but in any case the operation is right up here at the agglomeration point.

The spherodize process operates well below the agglomeration line A-B. We maintain our bed dry, usually about 1% to 1½% moisture, and there is very little agglomeration of particles. Control of the process, as far as the production of final pellet size, is based on a relation of the number and size of nuclei particles for a given amount of slurry.

The spherodizer is a piece of equipment that is essentially designed and built like a rotary dryer. It differs in several regards. It is usually on about a flat inclination, the attempt being to maintain a bed in the unit. It differs also in that the length for a given diameter is quite short. It has a short or small length to diameter ratio of the order of 2:1.

It further is a good deal smaller for the evaporation of the same amount of water. For instance, in a typical operation in which the inlet gas temperature is of the order of 600 degrees or 700 dgrees, we have found approximately 80 per cent of the heat has been exchanged and the moisture has been evaporated, both within 10–15 feet. This results from the majority of our moisture being evaporated by flash drying from the surface of particles and some spray drying of the atomized slurry within the gas stream.

We are flash drying the coating, from solid surfaces doing some spray drying of the droplets in the gas stream to form nuclei, as different mechanisms for drying in the spherodizer to replace in large measure evaporation from the interior of pellets in normal granular dryers. This accounts for the much smaller size of the spherodizers.

The fact that we are evaporating from the outside also gives us a substantial improvement in thermal efficiency as compared to normal rotary dryers. For instance, in a process in which conventional slurry granulators of nitrophosphates showed a thermal efficiency of the order of 32 per cent, units using the spherodizer, primarily because of lower stack loss due to high inlet temperature, because of the flash drying, show a thermal efficiency of the order of 70 per cent. In general, we can increase the thermal efficiency by 50 to 100 per cent frequently.

The interesting feature of the spherodize process is the uniformity at which the pellets are produced. This coupled with the fact that spherodizing does not require a circulating load of solids means that only the off size is recycle and that is small. We find in our small pilot plant work that the recycle and offsize material is of the order of 5% to 20% of the through-put. The larger plants run a larger amount of recycle, usually of the order of 50 per cent or one to one, one pound return for one pound of product extracted or slurry dry basis put in. This frequently reduces the size of a plant pelleting slurries to about one third its conventional size and is the spherodizer's outstanding characteristic.

Ammonium sulfate, potassium sulfate, potassium chloride, etc. are extremely difficult to pellet by conventional methods. These substances have been produced as uniform hard pellets with very low recycle by spherodizing; this is doubtlessly due to the different mechanism of pelleting of the spherodize process.

In other procedures for pelleting slurries it is normal not to remove all product size, but instead of recycle an amount of solid material back sufficient to absorb new slurry at about the agglomerating moisture. Only that portion of product size may be removed that is not required to absorb the slurry. With slurries of 20% moisture it is necessary to recycle from 6 to 14 tons per ton of product.

In summary, the advantages in pelleting slurry by the spherodize process usually accrue first of all to the low recycle rate which means all the subsequent equipment which usually amounts to several kinds of conveyors, classifying equipment, grinding equipment, is substantially smaller than in other plants and hence the first cost of the plant is reduced. This is augmented by the spherodizer replacing both the granulator and dryer and being smaller than the dryer would be in a conventional granulating plant. The second advantage is the high thermal efficiency due to the mechanism for drying. A third is a harder and more uniform pellet size and composition. Another advantage is application to unpelletable material such as ammonium sulfates, potassium sulfates and potassium chlorides.

Thank you.

MODERATOR REYNOLDS: Thank you very much, Ben.

Do we have any questions? I think we have time for a couple of questions here.

Ben, has this process been adapted to grades such as conventional mixed fertilizer and for the 12-12-12 or 10-10-10?

MR. SMITH: It has made both 12-12-12 and 10-10-10. Let me add that spherodizing is primarily a slurry pelleting process. When these grades or any grades are formulated so that a slurry, mud or magma results from mixing the raw materials before drying, then spherodizing in advantageous and a spherodize plant will be more economical. In those mixtures in which substantial water must be added to form a pumpable and sprayable slurry, it appears likely that spherodizing will only compete in the field of difficulty pelletable materials such as ammonium sulfate.

MODERATOR REYNOLDS: Mr. Hardesty.

MR. HARDESTY: You don't think then this would be applicable to mixed fertilizers? Is that the way I understood that?

MODERATOR REYNOLDS: The question is concerning the relation of this process to the mixed fertilizers, all mixed fertilizers.

MR. SMITH: Spherodizing as now practiced is not directly applicable to conventional mixed fertilizer pelleting. It would have to be modified by either adding substantial water to form a sprayable slurry of the raw feed or dividing the raw feed into a solid stream and a substantial slurry stream. Economic evaluation of either of these does not indicate advantages over conventional granulation.

MODERATOR REYNOLDS: Thank you very much, Ben.

Is there another question?

A MEMBER: What grades of ammonium phosphate have you tried on this?

MR. SMITH: We have tried it on 16-48-0, 21-53-0, 11-48-0, 16-20-0.

We have had poor experience plantwise with 16-20-0. We have been successful in the other grades. We have been, pilot plantwise, successful and we are making improvements in our 16-20-0 problem which was one of control.

MODERATOR REYNOLDS: Thank you.

MODERATOR REYNOLDS: Another question?

A MEMBER: Are the factors affecting the granulation sufficiently controllable that you would feel completely safe in designing for a one to one ratio of recycle?

MR. SMITH: We do not design for a one to one, and the design basis depends on the feed. Most of our experience is with nitrophosphate materials in which the slurry is of the order of 20 per cent water content. Those plants are usually designed at a two to one recycle rate. Some grades will operate, for instance, 14-14-14, at a recycle of somewhat less than one to one, half to one.

Other grades like 20-20-20 will operate closer to that two to one, which is the design basis.

MR. HUBERT H. TUCKER (Sohio Chemical Company): What is the temperature of the product in this gas?

MR. SMITH: We can put very hot gases into the spherodizer and within a matter of 10 feet, for instance, we can drop the temperature of the gas from 700 degrees F to 230 degrees F of gas temperature. Solid temperature under these very severe conditions are about 180 degrees F or 190 degrees F, maximum.

The temperature at the exit is of the order of 170 degrees or 160 degrees in the usual operation.

MODERATOR REYNOLDS: Okay, Ben. We thank you very much for this information.

MODERATOR REYNOLDS:

Our final paper on this afternoon's program relates to the handling of liquid sulphur. Mr. Robert Wernet, Chemical Engineer of Freeport Sulphur Co. will discuss this subject.

Liquid Sulphur Handling

Robert F. Wernet

GENTLEMEN, I would like to preface my remarks this afternoon on the handling of liquid sulphur with a little of the history of the transportation of liquid sulphur. The movement of liquid sulphur from mine to consumer by railroad tank car started in the mid 1940's. In 1946 Freeport Sulphur Company began inter-plant barge movements. This led, in 1955, to the movement of the first large tow, about 7500 tons, up the Mississippi River to a consumer's plant.

As the demand for liquid sulphur increased, it became apparent that the consumer could best be served from intermediate terminals located near the consuming plant. Therefore, liquid storage and trans-shipment facilities were established at strategic points by several of the major suppliers. The total storage capacity of these facilities is in excess of 220,000 long tons with the capacity of individual installations ranging up to 40,000 long tons. In addition to these facilities, suppliers maintain liquid storage well in excess of 100,000 long tons at their original shipping sites. The movement of liquid sulphur from base operations to the terminals is handled on the inland water-ways by large integrated barge tows carrying up to 10,000 long tons and by ocean-going tankers carrying up to 16,200 long tons. The over-all liquid program has grown to the extent that it is estimated that 50 percent of total domestic consumption is presently handled in the liquid form and that within a year up to 70 percent will move in this form.

Shipments to the consuming plants are made in ocean-going tankers, river barges, railroad cars, and tank trucks. The ocean tankers and river barges are equipped with heaters and pumps; therefore, to receive sulphur from these units requires only the make-up of a single pipe flange connection. The sulphur is maintained in the liquid form throughout the shipment, and discharge at the rate of 500 to 1000 tons per hour is started immediately after docking. Barge capacities range up to 2500 long tons or more.

Since freight costs limit truck deliveries to fairly short distances (up to about 100 miles), the sulphur here also arrives at the destination in the liquid form. These trucks are generally equipped with a steam-heated discharge valve and steam coil around the outlet nozzle connected in series. A steam hose with a quick coupling is required at the receiving site. Normally, no plant labor is required as the truck driver will connect the steam hose and, after steaming the valve for three to five minutes, will discharge the sulphur into the storage facilities. Truck deliveries are almost always made by gravity flow into storage facilities submerged in the ground. These facilities are usually a concrete pit equipped with steam coils to maintain the temperature. Truck capacities vary from 18 to 22 long tons.

Rail tank car deliveries usually arrive at their destination in a semisolidified state since heat cannot be provided during the movement. Therefore, some remelting time is necessary. The tank cars are generally equipped with two banks of steam coils. Screwed steam and trap connections must be made up. The steaming time will vary depending on travel time but will seldom exceed 20 hours. Tank cars are equipped to unload either through a bottom valve by gravity, or through a top eduction pipe using air pressure. The capacity of most tank cars is approximately 62.5 long tons.

Before proceeding with the various aspects of handling liquid sulphur, it might be well to review some of the physical and chemical properties of sulphur having a bearing on the subject. The freezing point of liquid sulphur is 238.1°F., its melting point is 246.1° F. Pure sulphur has a viscosity of about 10 centipoise at 255° F., and a minimum viscosity of about 6.5 at 310° F. At about 318° F. the viscosity starts to increase rapidly: 11.9 at 318° F., 11,900 at 325° F., 46,200 at 340° F., and a peak of about 93,000 at 370° F. Therefore, sulphur is normally handled at temperatures in the range of 260° F. to 290° F., which is safely between the freezing point and the point at which viscosity problems might develop. The specific gravity in this temperature range is about 1.79, a weight of about 111.8 lb./cu. ft. The presence of carbonaceous matter as well as temperature affects the specific gravity, but for design purposes 1.8 is a satisfactory value.

Since liquid sulphur contains no moisture or acidity, it can be stored and handled in mild steel, aluminum or concrete. Storage is usually either in concrete pits or insulated tanks. Heating is accomplished by means of carbon steel plate or pipe coils. It is generally not economical to build pits with a capacity in excess of about 500 tons. Therefore, they are used where receipt is from truck or tank car. For larger deliveries or where consumption is such that greater surge capacity is required, insulated steel tanks are used. These tanks are built in accordance with A.P.I. Specifications. It is preferred to have the filling line enter through the top and extend to within about a foot from the bottom. This line should be equipped with a vacuum breaker to prevent siphoning from the tank. Tanks presently in use range from about 100 tons up to capacities in excess of 10,000 long tons.

Both tanks and pits should be equipped with steam jacketed vents. This is necessary to prevent the possible built-up of explosive mixtures of vapors in the storage vessel. Most crude liquid sulphurs contain traces of hydrogen sulphide which, as you know, can form explosive mixtures with air. At this point, the question arises as to why hydrogen sulphide is often present in liquid sulphur. Frequently, this is a result of the reaction between the sulphur and the traces of hydrocarbon present. In the case of sulphur produced from sour gas, the hydrogen sulphide from which it is produced may be the source. Although not all sulphur contains hydrogen sulphide, it is safest always to assume that it is present and act accordingly.

The hydrogen sulphide, if present in liquid sulphur, is liberated by agitation. This is the reason for extending tank filling lines close to the bottom of storage tanks. With quick submergence of the line, agitation is minimized during filling operations. Even with this precaution, the atmosphere over the sulphur could reach explosive conditions during rapid filling unless adequate ventilation is provided. If sufficient venting area is provided, natural air circulation will normally prevent the build-up to an explosive mixture. The number and size of vents will, of course, depend on the tank size. We have found, for instance, that in a 90-foot diameter 10,000-ton tank sixteen eight-inch vents located around the periphery and two eight-inch vents near the center of the top give adequate ventilation.

In order to insure safe handling of liquid sulphur, pilot plant studies were conducted to determine the type of explosimeter that would indicate a rise toward an explosive atmosphere and at what reading the lower explosive limit was reached. These studies showed that the M.S.A. No. 2 explosimeter gave consistently reliable readings when properly maintained and that the lower explosive limit was reached at a reading of 70%. As a result, our Company's established policy requires the monitoring of the atmosphere in storage and shipping facilities with the M.S.A. No. 2 meter. To further insure safety, we use a safety factor of two and always suspend loading or unloading operations if the reading reaches 35%. Only after the reading drops below 15% are operations resumed. Under normal conditions, explosimeter readings will not exceed about 15% and are usually less.

The main design criteria for other handling facilities for liquid sulphur are adequate heating and choice of materials. Choice of materials comes down to the elimination of copper and copper base alloys throughout the system. Any copper alloy materials will react with sulphur to form sulphides with an accompanying increase in volume. In the case of valve and pump trim, this can cause seizing and equipment damage. In all other equipment, their life is so short due to corrosion that they can not be used.

Adequate heating can be accomplished with either steam or hot oil in jackets, tracers, or gut-lines. Small diameter pipe lines are generally jacketed or externally traced using special heat transfer cements. Large diameter lines may be either jacketed, externally traced, or equipped with gut-lines. In long flexible runs of large diameter pipe, internal gut-lines are frequently used to carry the heating medium. For short sections, such as pump manifolds, jacketed pipe is used even in large diameter since it is difficult to allow for gut-line expansion. Mild steel pipe is used for sulphur pipe gut-lines and jackets. Steel tubing is used for external tracing since sulphur fumes attack copper, and the heat transfer cements attack aluminum.

Suitably jacketed valves are presently available in most styles and sizes. For special applications, valves can be readily jacketed in the user's shops. The most important considerations in this case are adequate heating in the stuffing box area and proper location of steam and condensate connections.

Pump choice is normally dictated by volume and pressure equipment. For small volumes and high pressures either plunger pumps or gear type pumps are used. Stuffing box maintenance can be a problem unless special care is taken to insure adequate heating in this area. Where design permits, centrifugal pumps of either the vertical submerged or horizontal type are used. With vertical submerged pumps, only the discharge pipe and shaft cage need be jacketed. With horizontal centrifugal pumps, the entire case must be jacketed. With this type pump, the use of mechanical seals has virtually eliminated the stuffing box problem.

To sum up — the handling of liquid sulphur is relatively safe and simple if proper precautions are taken in the design and operation to insure adequate venting and monitoring of storage facilities and proper temperature control in all facilities.

MODERATOR REYNOLDS: Thank you very much Mr. Wernet. Do we have any questions? I think we have time for a couple of questions.

Mr. John G. Schroder, Technical Manager of Australian Fertilizers Ltd. then asked a question. Is molten or liquid sulphur offered other than in the U. S. at present.

MR. ROBERT WERNET: As of the present time molten sulphur or liquid sulphur shipments are not being made by international movement except within this hemisphere. It has been and is being investigated at the present time, the possibility of moving liquid from this country abroad.

MR. SCHRODER: The size of tanker that you use.

MR. ROBERT WERNET: The range is in the vicinity of 16,000 long tons, from 15 to 16,200 tons. The three tankers presently in service are all converted to oil tankers and run in that range.

MR. SCHRODER: Can they be used to back haul or must they come back empty?

MR. WERNET: This is something that will probably affect whether they can handle shipments outside of the country. At the moment they are not used for back haul because of contamination problems. One of the big advantages of receiving molten sulphur is the elimination of contamination and, as a result, to use the same tanks for other materials cause you to lose some benefit.

MR. SCHRODER: Any difference in price?

MR. WERNET: This I can't say; this is not my department.

MR. SCHRODER: And why not use an inert gas generator, an ordinary petrol engine just to put some gas in there?

MR. WERNET: As it happens on the tanker that moves our sulphur we use an inert gas system at the tanks on the ship. However, we have found that for plant facilities at our own locations, at the mines, our shipping sites and various terminals that it isn't necessary to go to this extent, that with normal ventilation with adequate vent ports on the tanks you can eliminate any explosion problems and therefore the added expense of inert gas systems is not warrented.

MODERATOR REYNOLDS: One more question?

MR. JOSEPH F. PISCO, Industrial Engineer (Standard Oil Company): This is a little more detail in reference to the question which was just asked. I just wonder, how far have you carried sulphur in T-2 tankers?

MR. WERNET: From our main shipping point, Port Sulphur, Louisiana, across the Gulf and up the East Coast as far as Bucksport, Maine, serving a terminal in that area which serves the paper industry throughout the New England States, serving terminals at intermediate points all along.

MODERATOR REYNOLDS: Thank you again.

You have been a very attentive audience. We have completed today's program. I really appreciate your staying with us and your cooperation.

We are adjourned until tomorrow morning at nine thirty.

(The meeting adjourned at five o'clock p. m.)

Friday Morning Session, Nov. 10, 1961

The Round Table reconvened at nine thirty o'clock a.m.
Mr. Albert Spillman, Moderator, presiding.

MODERATOR SPILLMAN: Good morning all of you.

I wish to take this opportunity, on behalf of your Executive Committee and all of Our Membership, to thank Tom Athney and his Associates, of The Raymond Bag Co., for the very fine party they gave our entire membership last evening.

An effective fertilizer plant safety program is one of the most productive investments we can make. This morning we are fortunate to have Mr. Roy G. Benson, Manager of the Industrial Department of the National Safety Council, Chicago, Illinois, who will discuss with us how to create and maintain interest in plant safety. Mr. Benson has been a member of the National Safety Council staff since 1948. He is Technical Editor of the National Safety News and Secretary of the Industrial Conference; the Policy-making Committee of the Safety Council, industrial programs. He holds patents on a number of safety devices. Prior to joining the National Safety Council, Mr. Benson was on the Council staff and had operated his own safety equipment sales organization. He was Safety Director of an oil processing research organization and a Safety Consultant to the aviation gasoline industry. He is a member of the American Society of Safety Engineers and his interests are with many other safety activities. Mr. Benson is well qualified to discuss the subject assigned to him and we appreciate his appearance on our program this morning. I give you Mr. Benson:

MR. ROY G. BENSON (National Safety Council): Mr. Spillman, please don't walk off with my notes. I left the other set of notes in a cab in Chicago, so last night, at ten o'clock, I had to rewrite the talk. I wonder how it's going to turn out? It's like the guy who dreamt that he was speaking in the ballroom of the Mayflower Hotel and when he woke up, he was. (Laughter.)

At another meeting of psychiatrists, that was held at one of the big hotels here, two pigeons flew in and it was two hours before anyone would acknowledge they were there.

(Laughter.)

How to Create and Maintain Interest in Plant Safety

Roy G. Benson

COMPARED to the complete discussion that you all had the last few days involving processes and reactions, my topic is simple. My subject is SAFETY, and I want to tell you why it isn't a readily acceptable subject. I hope that I'll be able to show you that it can be digestible if not immediately palatable — if leaders will accept their responsibility.

It took me many years, working as a Safety Engineer, to learn that even learned individuals were not safety-minded, in fact, at times they are so intent on getting the job done that they would not only overlook, but deliberately neglect, safety precautions.

For example, in a research laboratory, where I was responsible for the accident prevention program, we were fortunate to have a world renown catalytic chemist. Early in his career he had isolated one of the radio active elements. Yet this man, who should have placed the highest value on his eyes, hands, lungs — even his life, had to be repeatedly admonished for his safety misdemeanors. In his anxiety to get a research job done he would run an experiment under pressure in a glass vessel. Or, he would ask his lab assistants to conduct some other equally hazardous project. Questioned, he would shrug and say "all we were trying to do was to get some results." At that time, this was accepted practice in this particular research establishment. A few hundred mishaps later, this had changed. This same laboratory at the present time has all sorts of regulations so work of that kind just can't be performed. But this was twenty years ago, and we hadn't learned to talk and work with people and that results or even production can be obtained and people don't have to get hurt in the process.

I have to think about my own feelings regarding safety to try to convey what has to be done. For example, I have two children and I recall when Dan, my son, was real small and there was a 'fiesty' kid living next door and he took a slap at Dan. If I had been a good safety man, then I would have said, "look Dan, let Carl alone: don't monkey around with him, because if you get into a real fight, he's liable to hit you in the eye and damage your eye, or he's liable to pick up a rock and even fracture your skull . . . so just avoid him."

I did not act like a safety man; I did exactly what all of you would do. I said, "go over there and slap *him* down" and I didn't even think about the consequences. This is the way we are all brought up, we don't admire the cautious guy, we admire the guy who sticks his neck out . . . the guy who takes chances!

We go out to a sports arena and who do we cheer? We certainly don't yell for an outfielder on a team who, when he sees he's getting close to the fence, shies away and lets the ball drop. We clap and cheer though for that guy who bounces off of the fence and even though he's laying flat on the ground knocked out after the play he's still holding the ball!

On the White Sox's team in

Chicago we have a little second baseman named Nellie Fox. We like Nellie because he's a tough little guy who stands out there on second base and he completes the double play and doesn't worry about the spike coming at him until the play is over . . . every once in a while he gets scratched up but even that doesn't stop him.

Those are the kind of people we admire!

There is one public hero that I like to talk about—because given a few years, I could have been involved in his exploit. The event and the individual was Charles Lindbergh and his trans-atlantic flight—he accomplished something rather significant he paved the way for transoceanic flights. At one time I was safety director for an oil company and as such could have taken part in the following episode. I could have had an advertising man come to me from the oil company and say, "Roy, we've got a young man in here that's got a terrific idea. We think it's got a lot of public relations interest. This guy thinks he can take a single-engine palne and fly it across the ocean, and he says if we put a certain amount of cash in, he will use our gasoline and we'll get a heck of a lot of publicity. If he makes it, the newspapers all over the world will carry the story and we can have our product name in every newspaper in the world!"

I would have said, "what do you want me to do?" — "I'm the safety man." His answer would have been — "well there's some safety aspects and I wish you'd go into it more, talk to the guy, because he's got some ideas that are just a little bit different."

So, I could have talked to Mr. Lindbergh and I would have asked him how come no one else has ever tried this stunt? — and he'd tell me that his kind of plane couldn't fly that far. Then I'd ask — "well, how are you going to make it?" "Oh, I'm going to put in extra gasoline." "Where are you going to put it?" I'd ask . . . and he'd tell me he was going to put them in the only place they'd go up in the cockpit all around him. And if any of you read the story, perhaps you'll remember that that is exactly what he did . . . the extra tanks of gas were in the cockpit with him.

"How are you going to see with all those tanks around you?" I'd want to know. "I've got a kind of periscope arrangement," Lindbergh would explain.

When we started to calculate the load that he was going to carry and the lift of this particular plane, and that those two critical factors are so close together that it's an even chance that he won't get off the ground we'd be forced to call that advertising man and say, "Joe, that's a good idea, but, as a safety man, I've got to put thumbs down on it, because this guy has only got a 50-50 chance of even getting off the field — it's just not safe" I'd continue. "*You* can see this picture of the plane landing in Paris with our name emblazoned all over it — I can see this guy in a great big flaming heap at the end of the runway and our name emblazoned alright, and the light is furnished by our burning gasoline". "So for safety's sake Joe, I've got to turn thumbs down on the idea."

You all know what Lindbergh did, he got away with it, and it was a great accomplishment. Hardly anyone remembers that he did just get off the field with his heavy load. Now I've got to leave this line of thinking because if I continue I'll go back to the National Safety Council and say, "It's no use me spending the rest of my life trying to sell safety, because people don't want it."

But this is not true, because I have learned a number of things, in this country and especially in this industry safety can and does work — and as our moderator said, it proves profitable in many ways to those people who apply it, use it, understand it. But you have to realize first, that people are going to reject it and it takes a lot of selling!

For instance, we know that people must take some risks, that it's impossible to say you'll never take a chance. I had to take to chance to come to Washington. I left Chicago and came here by 'plane. I could have taken a lesser risk, but there was the time element involved, so this had to be a consideration.

The overall results as far as industry in this country, are good. In fact, they are *so* good that countries all over the world look at us. I know this because they come into our offices, trying to find out how they can start programs in their own country, how they can apply the same principles of industrial safety that doesn't exist elsewhere.

Within the last month I have seen some safety material that has come back from the iron curtain areas. Like all their other claims they boast about safety. The words are fine but safety men are used to inspection, and the pictures reveal the absence of necessary features that would constitute a basic program. Knowing from experience that good safety programs are founded on understanding management policy it is easy to see this can only happen in a country where the individual counts.

Management in this country, has accepted its leadership, and in so doing has overcome the attitude toward safety rejection which I outlined previously. Not only have they assumed their leadership at the present time they are going well beyond industrial plants . . . now the concentration is on Off-the-Job Safety programs!

How do we stimulate people to work in a safe manner? We first have to understand people. I think we have to realize that the majority of people do have some safety awareness and most of the people go year in and year out without an accident.

We have to concentrate on avoiding that lax moment when tripping, falling, bumping into objects or some other simple act can produce an accident. Everyone including the fertilizer industry, says they are different . . . yet 75 to 80% of all accidents are common to all industries. Ridiculously simple things like taking an extra step and falling down off of this platform, like bumping into a beam or leaving a guard off. In all industry, these are the types of accidents that occur most.

So that you can look at what others have accomplished in almost any industry and learn. We attack worker attitudes on the National Safety Council level, with a variety of materials. For example, we try to approach safety with humor because there are a certain amount of people that just have to be reminded.

We know that we cannot do everything in a humorous fashion, because we can't laugh off the whole subject of safety and treat it always in a light vein. Some people would not respond to this treatment.

Let me try to give you some illustrations. In the textile industry there were a lot of accident experiences in the carding room. A carding machine in the textile industry is a machine that's enrobed with a lot of fine wires like a currycomb, and if you get your hand caught between the rollers it will strip the flesh off very effectively. Of course, the instructions were to shut the machine down before you did any work on it. In this particular mill close to ten people had had serious hand injuries in one year.

They had pictures taken of all these hand injuries and they placed them around the walls of the plant. From the day that they were posted up they shut off all accidents of that kind! At last check the pictures were still there and no accident of this type had happened for three years.

But you do have to find out the type of people you have to deal with, give them the treatment they need. Everyone doesn't fall for the same sales approach when purchasing a car or a radio, and the same follows for safety.

There are ohter people, for example that can be approached by clutching at their heart strings. They have a deep feeling toward their family, their children and yet may resent an approach that shows concern for their own well being. They have a concern for what might happen to their family *if* something happens to them. So we utilize this concern in a way similar to the approach that might be used by the guy that's selling a monument or insurance and turn the sales pitch toward safety.

One of the most difficul questions we have to answer is, "what kind of safety program should we have in our company or our plant?" This can only be answered by someone who knows the people in the plant. You know your own people — no one in Chicago can tell you how the people in a plant in North Carolina will react to a training program or even to a poster.

In the South I worked with the textile industry for a while. We recognized the fact that you can inject a great deal more religion into a safety program in the South that you can in Chicago, New York or Pennsylvania — and very often you see a meeting start with a prayer.

I remember a man who came from the Dutch reform area of Michigan and came to Chicago and started a safety meeting with a prayer. Three or four guys came in just ahead of me and they backed off — saying, "we must be in the wrong place". They had never heard of a safety meeting being started with a prayer. Yet this is common practice in the South.

So you learn to use all these devices, all the devices you can assemble. A safety director of a steel mill who was trying to put across a hard hat program had many Latin Americans working in the plant. As long as he was just offering the brown hard hats he was getting no place. Then all of a sudden he said, "Okay, we now have hard hats in red, green, blue, any color you want." Since this racial group has a great love for color, it was a natural and his hard hat program blossomed.

Some years ago you could only buy one type of safety goggles. This was a 50 millimeter round safety spectacle. It had a great big mark on the lens and if you looked at a guy from ten feet away, you could tell he was wearing safety glasses.

At the present time, I could be wearing a pair of safety glasses in these frames and nobody would know that they were safety glasses, because they have learned that style is important. The same applies to safety shoes. One thing we have learned is that when people have to wear protective equipment, they want to wear what they are wearing normally, all the time, not some ridiculous special creation! They want the protection but don't want to look ridiculous when wearing it.

So we take all of these things into consideration in trying to create and maintain interest in safety. We use the fact that pride in important. Companies vie for the honor of being the safest plant, departments vie for the honor of being the best and safest department.

You don't even realize that I am wearing a safety symbol on my tie, because it is a program that we have been developing over the last couple of years and it was developed from the traffic triangle, or I should say, the traffic diamond. This is the program developed by the Allis-Chalmers Manufacturing Co. they made a film "SAFETY EVERYWHERE . . . all the time" and the idea was to have a motivating film that would create a lot of interest and then have a recall device in this diamond shape. Booklets, banners, posters and other recall devices tied into it. It's no different from any other advertising campaign. Any one of your products, if you want to promote it you will use an identifying symbol and by sheer repetition will serve to keep reminding people until the product gets fixed in their minds.

So we pull out all the stops! We tickle their fancy, we slug them, we pluck at their heart strings, we play on their racial weaknesses, we play on their stylesense and we can use anything that an advertising or any merchandising man might use to sell his product. Never forgetting that at first people resent what we have to offer.

One safety program in this country that I think everybody recognizes as a good program is the Du Pont Company program. And I think I can tell you why it's a good program . . . they have a fine brochure called "Safety Starts Here," this is a series of statements, letters written by the Chairman of the Board, the President of the Corporation and the Presidents of all of the separate companies of the du Pont organization. Each one of them has a written and signed statement about safety. If management issues a policy and even writes out a policy, they are going to be pretty sincere about it because they have to put it on record.

You can be sure that all employees under them understand and apprecate the sincerity. Supervisors will assume their responsibility, and as a natural sequence the workers will accept their program because they know that it is based on sincerity.

I believe that the fertilizer industry should be complimented — this is one industry that is doing something about supervisory training, they intend, I believe, to run four courses for supervisors in various parts of the country. There are fifty or more supervisors in each one of these groups, and for this the industry as a whole is highly commended.

In concluding, I would like to impress you with the fact that everybody follows a leader, and I don't think that I have ever given an award to a company until the individual worker, the guy who is doing the job has come to the realization that "my supervisor doesn't want me to get hurt!" when the workers finally accept this fact they start to act in a safe manner, be concerned about their fellow workers and accumulate man-hours without lost-time injuries. Where a whole industry through a trade association decides it needs a safety program they find that the best approach is to attack the big targets in their particular type of work.

For example, in the mining industry falls of ground is the leading source of serious injuries, and they have run two or three campaigns on how to train miners to test the roof before going to work in the area. The mines that have participated in programs of this kind have had 25 to 30 percent reduction in the number of injuries from that particular cause. This becomes most significant when you can count the number of fatalities that have been prevented.

The logging people also have a big problem — that of falling limbs and the necessity of wearing hard hats, so they have recently established a program on the wearing of hard hats.

In the electrical and public utilities industry we have an electric shock program underway.

Each respective industry has to figure out some area that is their prime target and then work in that area . . . in that way they can cure their accident producing ills.

((Applause.)

MODERATOR SPILLMAN: This guy Benson is a pretty busy man. I just received a message for him. "Mr. Roy Benson, National Safety Council, Mayflower Hotel, Washington, D.C. Suitcase has been found. Picking it up today."

MR. BENSON: Al, you thought I was kidding that I had lost my notes. I did. Thank you.

MODERATOR SPILLMAN: A good many of our members are associated with the fertilizer section of the National Safety Council. If any of your respective companies are not members of this section, I highly recommend that they join the Safety Council at the earliest moment. I am sure most of us responsible for plant operations are doing a continuous job preaching and practicing safety in the plant. Mr. Benson, we wish to thank you. All of us appreciate your excellent, inspirational message on safety.

Are there any questions for Mr. Benson?

MR. E. M. JONES (Allied Chemical Corporation): Al, not a question. The dates for the Midwest Supervisory Training School are November 30 - December 1 at the National Safety Council Headquarters in Chicago. The Northeast Safety Council, I believe, is the following week and it will be held in New York City at the School of Industrial and Labor Relations. The Southeast Safety Council has been completed. It was held in Wilmington, N.C. The fourth school is the West Coast School, and I believe that will be held in Fresno, California, later on this year. Thank you.

MODERATOR SPILLMAN: Thank you very much, Mr. Benson.

Mr. Travis Hignett will lead the panel on our final very important subject of Materials Handling Program "Composition and Use Of New Materials In Fertilizer Formulation." We have received from our membership a number of pertinent questions on the use of granular materials in conventional, semi-granular, granular and blended mixed goods.

Some of the questions are: How can segregation be prevented? How can granular materials be handled and stored to hold down attrition to a minimum? What precautions should be taken when formulating with Diammonium Phosphate to reduce nitrogen losses? What information is available on disassociation of nitrogen losses in mixtures containing various types of Diammonium Phosphates? The proper handling of mixed goods, made from Blended granular materials, to maintain a more uniform product from plant to farmers' fields, either in bags or bulk?

I am sure, after the panel completes their presentations, you folks will have many more questions you wish to have answered.

The panel, in addition to Travis Hignett, are Dr. George E. Smith, Department of Soils, University of Missouri, and Philip E. Stone, technical assistant to the vice president, Virginia-Carolina Chemical Company.

Composition and Use of New Materials in Fertilizer Formulations

Travis P. Hignett

The new materials that the panel will discuss consist of a group of granular, high-analysis products containing both nitrogen and phosphorus. These N-P materials may be subdivided into two classes: (1) the diammonium phosphate materials 21-53-0, 18-46-0, and 16-48-0 and (2) the high-nitrogen N-P materials 30-10-0, 20-20-0, and 20-10-0.

The diammonium phosphate group of new materials is of particular interest as shown by the number of questions sent in by the membership of the Round Table and by the large annual tonnage of these products and the number of new plants that are planned or being constructed to produce them. Our panel plans to devote most of our discussion to these materials.

A principal use of the new materials is in bulk blends, and several questions about the problems of bulk blends have been received. We are fortunate in having on our panel a man who has devoted careful study to the problems of uniformity of composition of blends and affected by the properties of the ingredients and the mixing, handling, and application procedures. We also have several questions about the use of the new materials in chemically processed mixed fertilizer, and some of the panel members will comment on these problems.

Before discussing the use of the new materials, it seems appropriate to review briefly their properties and composition.

Messrs. Carnell, Tatem, Phillips, and Giles gave detailed information on the composition, properties, and manufacture of the diammonium phosphates at the 1960 Round Table meeting. The 18-46-0 and 16-48-0 products are essentially ammonium phosphates produced from wet-process phosphoric acid. The 18-46-0 contains 90 per cent or more of its ammonium phosphate content in the form of diammonium phosphate, and the 16-48-0 may contain 70 to 80 per cent. Both products contain about 10 per cent of their P_2O_5 content in the form of complex water-insoluble phosphates derived from the impurities in the wet-process acid. Although these complex phosphates are water insoluble, they are mainly citrate soluble and have been found to be effective fertilizer materials.

The 18-46-0 and 16-48-0 are produced in the form of rounded, closely sized granules. The particle size is between 6 and 16 mesh and is often more closely sized such as 6 to 12 or 8 to 14 mesh. In one sample that we received, 85 per cent of the product was 8 to 10 mesh. The bulk density of these products ranges between 60 and 65 pounds per cubic foot.

The 21-53-0 material is essentially pure, crystalline diammonium phosphate made from electric furnace phosphoric acid. It is entirely water soluble. It is available in the form of crystals sized at about 6 to 16 mesh or finer. The bulk density of the 6- to 16-mesh crystals is about 62 pounds per cubic foot.

Incidentally, the bulk density figures are probably not comparable since rather wide variations in measured bulk density may result from different degrees of packing and other variations in procedure. Perhaps some standardization would be desirable. Density may be important in predicting behaviour of materials in bulk blends. For this purpose, it is suggested that apparent specific gravity would be more useful than bulk density.

The 30-10-0 products contain about 78 per cent ammonium nitrate and 17 per cent monoammonium and diammonium phosphates. They also contain a small percentage of inert conditioner. The products are rounded granules or prill-like granules with a particle size range of 6 to 16 or 8 to 16 mesh. The products are entirely water soluble except for the conditioner. The reported bulk densities range from 47 to 51 pounds per cubic foot.

The production of 20-20-0 and 20-10-0 was described here last year by Mr. Giles.

These products are nitric phosphates, although it is possible to make the same grades by other processes. The nitric phosphate products are sized at 6 to 12 mesh. They contain ammonium nitrate, monoammonium and diammonium phosphate, and dicalcium phosphate. The 20-10-0 product also contains calcium sulfate.

An important use of the new materials is in bulk blends. This is especially true of the diammonium phosphates. Bulk blending is increasing rapidly because of its economic advantage over chemically processed mixed fertilizer. Silverberg (3) estimates that the cost of bulk-blended fertilizer at several locations is about $0.25 to $0.30 per unit less than that of comparable bulk, chemically processed solid or liquid mixed fertilizers. The new materials are especially well suited for bulk blending because of their high analysis, physical form, compatability with other materials used in bulk blending, and low cost per unit of plant food. Diammonium phosphate and 30-10-0 have been identified as ingredients of least cost bulk blends (1).

The partcile size and shape of the new materials provide a good match with some of the available granular potassium chloride and with prilled ammonium nitrate or urea. Thus, it is possible to select materials for bulk blends that should not segregate. The use of two-nutrient materials in bulk blends may help minimize any nonuniformity of nutrient supply in the field that may result from segregation.

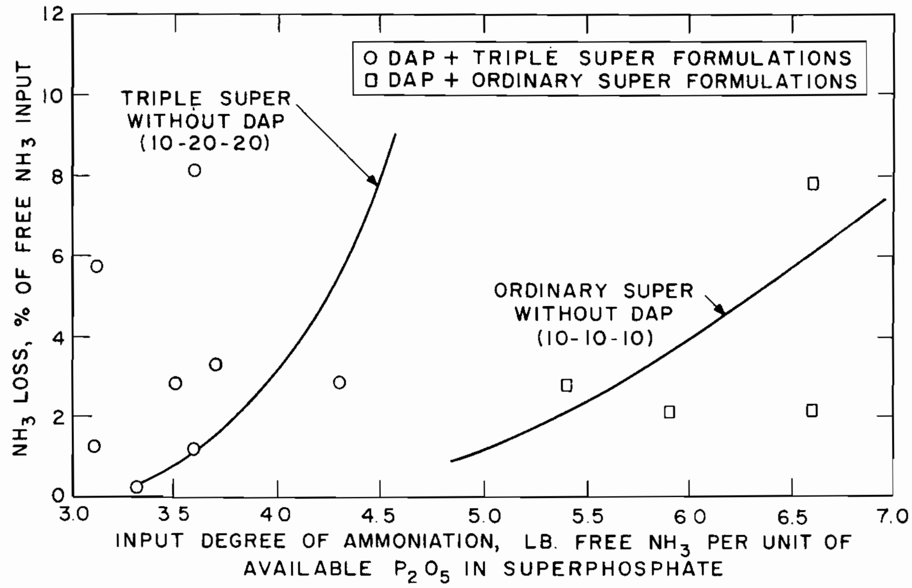
Some of the new materials have found widespread use in the manufacture of chemically processed mixed fertilizer. Diammonium phosphate often is used for this purpose. One of its advantages is its very high analysis which enables the manufacturer to upgrade his products or alternatively to use more low-cost superphosphate in standard grades. As compared with an equivalent amount of phosphoric acid and nitrogen solution, the delivered cost of the diammonium phosphate is often lower, and it is easier or cheaper to store and handle. Also, it contributes less water and heat to the formulation which may be an advantage in some cases.

Pilot-plant studies in which diammonium phosphate was used in formulations to produce high-analysis granular mixed fertilizer have been reported by TVA (2). Some of the grades that were made successfully in the pilot plant were 12-24-12, 16-20-0, 15-30-0, and 8-24-24. This paper also gives some discussion of the economics of such formulations.

Some questions have been raised concerning the stability of diammonium phosphate and its effect on nitrogen losses during processing and storing of mixed fertilizer containing it.

The stability of diammonium phosphate was discussed at the 1960 Round Table meeting by Mr. Tatum. I think we may summarize this information by saying that diammonium phosphate is quite stable under reasonable conditions of processing and storage. No appreciable nitrogen loss would be expected to occur due to dissociation of diammonium phosphate under practical conditions. Granular mixed fertilizers containing diammonium phosphate such as 20-20-0 and 15-30-0 have been stored at temperatures up to 180° F. for periods up to 90 days. No nitrogen loss was detected even under the most extreme of these conditions. We believe that nitrogen losses from mixed fertilizers containing diammonium phosphate are quite unlikely except in the case of high-moisture mixtures containing limestone or other alkaline materials.

There remains the question of the effect of the presence of diammonium phosphate on the absorption of ammonia by superphosphate. It is known that diammonium phosphate will react with superphosphate. Typical reactions are:



AMMONIA LOSS vs. DEGREE OF AMMONIATION FOR GRANULAR FERTILIZERS FORMULATED WITH AND WITHOUT DIAMMONIUM PHOSPHATE

Figure 1

Reactions Of Diammonium Phosphate With Superphosphate

$$Ca(H_2PO_4)_2 \cdot H_2O + 2(NH_4)_2HPO_4 = Ca(NH_4)_2(HPO_4)_2 \cdot H_2O + 2NH_4H_2PO_4 \quad (2)$$

$$Ca(H_2PO_4)_2 \cdot H_2O + (NH_4)_2HPO_4 = CaHPO_4 + 2NH_4H_2PO_4 + H_2O \quad (1)$$

Reaction (1) is the familiar ammoniation reaction in which the ammonia is supplied by one of the two ammonia groups of the diammonium phosphate. Reaction (2) is similar except that it shows the formation of a double salt which actually was observed in our studies.

If the reaction between diammonium phosphate and superphosphate proceeds to an appreciable extent, it will decrease the amount of free ammonia that can be absorbed, and consequently, high ammonia losses will result if it is attempted to ammoniate the superphosphate to the usual degree of about 5.8 pounds of free ammonia per unit of P_2O_5 in ordinary superphosphate or 3.8 for triple superphosphate.

In the pilot-plant studies that were reported by TVA (2), it appeared that the presence of diammonium phosphate did not appreciably affect the extent to which superphosphate could be ammoniated without excessixe loss. It was concluded that the rate of reaction of diammonium phosphate with superphosphates was so slow that it could be ignored.

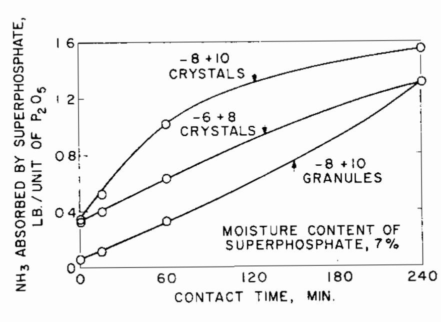
Figure 1 compares the ammonia loss in the pilot-plant production of granular fertilizers when triple or ordinary superphosphate was ammoniated with or without diammonium phosphate in the formulation. Although the points for the diammonium phosphate-containing formulations are scattered, there is no clear tendency toward high ammonia losses. In some of the individual runs, high ammonia losses were believed to be caused by excessive ammoniator temperature or overagglomeration. In these tests the diammonium phosphate and superphosphate were fed from separate feeders to a belt which fed the continuous ammoniator. The two materials were in contact with each other only a few seconds before ammoniation.

Subsequently, a test was made in which the superphosphate was premixed with diammonium phosphate several hours before it was ammoniated. In this test the ammonia absorption was poor, and there was evidence of extensive reaction between the diammonium phosphate and superphosphate before ammoniation. This observation led to a study of the rate of reaction.

The factors studied were the particle size and form of the diammonium phosphate, the moisture content of the superphosphate, and the time of contact of the two materials.

Typical data obtained in these tests are shown in Figure 2. When the superphosphate contained 7 per cent moisture and when the diammonium phosphate was coarse, the extent of the reaction in 15 minutes corresponded to ammoniation of the superphosphate to a degree of 0.1 to 0.5 pound of am-

Figure 2



REACTION OF ORDINARY SUPERPHOSPHATE WITH DIAMMONIUM PHOSPHATE

Before contact **After contact for 30 minutes** **After contact for 60 minutes**

Fig. 3. Photomicrographs of diammonium phosphate crystals before and after contact with ordinary superphosphate

monia per unit of P_2O_5. The reaction was more rapid with 21-53-0 crystals than with 18-46-0 granules and more rapid with 8- to 10-mesh crystals than with 6- to 8-mesh crystals. The reaction continued as the time of contact was extended and reached values of 1.3 to 1.5 pounds of ammonia per unit of P_2O_5 after 4 hours. The proportions of diammonium phosphate and superphosphate were such that conversion of all of the diammonium phosphate to monoammonium phosphate would release enough ammonia to ammoniate the superphosphate to a degree of 7 to 8 pounds of ammonia per unit of P_2O_5. Thus, the reaction after 4 hours was about 20 per cent complete.

In these tests the diammonium phosphate was mixed with minus 20-mesh superphosphate, and the mixture was allowed to stand for the desired contact time. Then the diammonium phosphate was separated from the superphosphate by screening. Both fractions were analyzed to determine their water-soluble P_2O_5 content. The extent of reaction was calculated from the decrease in water solubility.

The points shown in Figure 2 near the zero ordinate are for 0.5 minute's contact time. However, some of the superphosphate adhered to the diammonium phosphate granules or crystals and was not removed by screening. The adhering superphosphate probably continued to react so part of the reaction indicated in Figure 2 probably occurred after the indicated contact time. This circumstance may have caused a large percentage error in the extent of reaction for short contact times, especially for 0.5 minute, but absolute error would not be large.

Microscopic examination showed that the crystalline diammonium phosphate absorbed moisture from the superphosphate. A film of liquid phase quickly formed on the surface of the crystals which promoted reaction. The granular diammonium phosphate also absorbed moisture, but it was drawn into the interior of the porous granule and did not immediately form a film of liquid phase at the surface. This observation explains why the reaction of granular diammonium phosphate was initially less rapid than with crystalline diammonium phosphate.

Figure 3 shows photomicrographs of diammonium phosphate crystals that have been in contact with superphosphate for 0, 30, and 60 minutes. As the reaction time was increased, the hull of reaction product around the crystals grew thicker. The hull was comprised predominantly of $Ca(NH_4)_2(HPO_4)_2 \cdot H_2O$ (dicalcium diammonium phosphate monohydrate). There was a very thin inner hull of monoammonium phosphate which is not clearly visible in the photograph.

A few tests were made to study the effect of the moisture content of the superphosphate on the rate of reaction with diammanium phosphate. When the superphosphate contained only 4.3 per cent moisture, no detachable reaction occurred in 1 hour. When the superphosphate contained 9 per cent moisture, the reaction with 8- to 10-mesh granular diammonium phosphate was appreciably more rapid than with superphosphate containing 7 per cent moisture.

Since the time of contact of the dry ingredients before ammoniation in most plants probably is less than 15 minutes, it appears that the extent of reaction of coarse diammonium phosphate with the superphosphate would be quite small, and that no significant effect on ammonia absorption capacity would be expected. Perhaps with longer retention time or with fine diammonium phosphate, an appreciable extent of reaction would occur which would require some adjustment of the free ammonia supplied by the formulation to prevent excessive ammonia loss. It is desirable to ammoniate the superphosphate fully in mixtures containing diammonium phosphate; incomplete ammoniation may result in reactions after processing that may cause disintegration of the granules, especially if the moisture content of the product is high.

A further study of the ammoniation of superphosphate in the presence of diammonium phosphate was carried out in the bench-scale ammoniator-granulator shown in Figure 4. It was 10 inches in diameter by 20 inches long and rotated at 40 revolutions per minute. The ammoniation section was 7 inches long, and the bed depth in this section was 2.5 inches.

One and one-half parts of superphosphate were premixed with one part of 6- to 20-mesh crystalline diammonium phosphate (21-53-0) or 8- to 10-mesh granular diammonium phosphate (18-46-0). The contact time of the mixture before ammoniation was 15 to 30 minutes. Comparison tests were

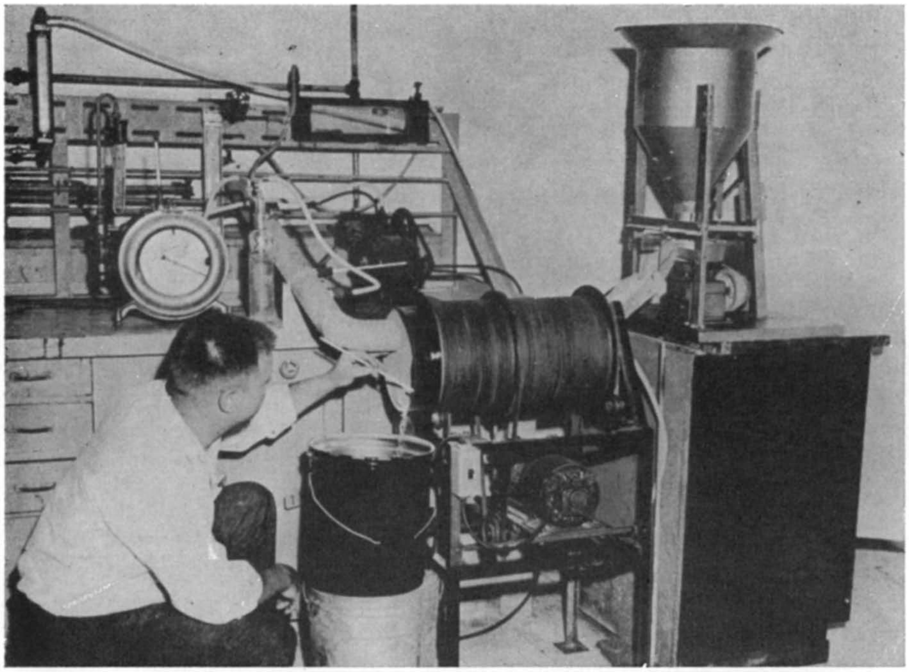


Figure 4. Small-scale equipment used in ammoniation-granulation studies.

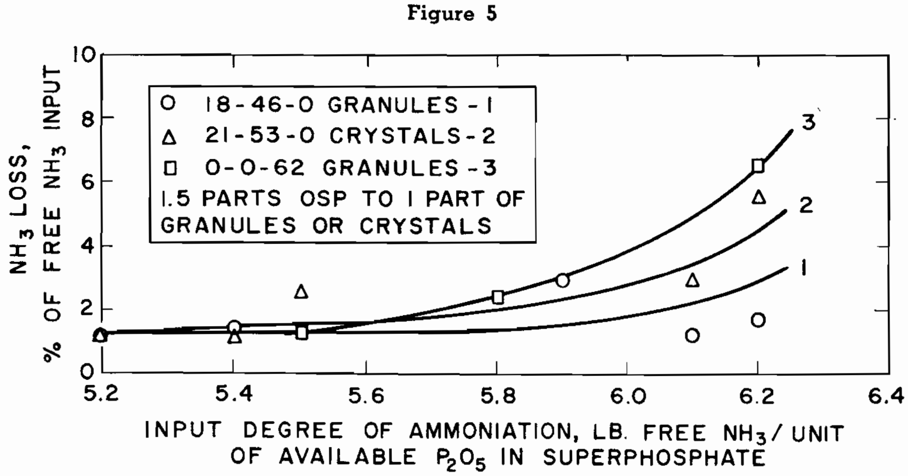
made in which the superphosphate was mixed with a like amount of granular potassium chloride.

The mixtures were fed from a disk feeder at a rate of about 20 pounds per hour. Gaseous ammonia was introduced under the bed through a drilled pipe distributor. Steam was added through a separate distributor to control granulation. The ammonia content of the exhaust gases was determined and used to calculate the ammonia loss.

Since it is known that the ammonia absorption is affected by the extent of granulation, temperature, and moisture content, these variables were held as nearly constant as was feasible. It was not feasible to control these variables independently or closely since the moisture content and temperature affect granulation. Each test was run under conditions that gave a reasonably good degree of granulation; the moisture content of the products ranged from 5 to 9 per cent, and the temperature ranged from 180° to 200° F.

The results of these tests are shown in Figure 5. The points are somewhat scattered, but the data indicate the ammonia loss was not increased by the presence of diammonium phosphate. These curves are similar to those obtained in pilot-plant studies when using granulation formulations and indicate that a degree of ammoniation of about 5.8 can be used without loss of more than 3 per cent of the input ammonia. The most uniform granulation was obtained in the tests with 18-46-0, which may explain the slightly better ammonia absorption in the tests with this material. The uniform granulation was due to the fact that the 18-46-0 granules were closely sized and became uniformly coated with ammoniated superphosphate during ammoniation. The 21-53-0 and the granular potassium chloride were less uniformly coated; some uncoated particles appeared in the product. Probably the surface of the crystalline materials was too smooth for good adherence of the coatings.

Figure 5



EFFECT OF DIAMMONIUM PHOSPHATE ON AMMONIA LOSS DURING AMMONIATION OF ORDINARY SUPERPHOSPHATE IN BENCH-SCALE TESTS

The 30-10-0 product has found some application as an ingredient of mixed granular or semigraular fertilizer grades. It can be used in normal ammoniation-granulation equipment in conjunction with ammonia or ammoniating solution and superphosphates to make high-nitrogen grades such as 20-10-10, 21-14-7, 20-10-5, and 15-15-15. In such formulations the granules of 30-10-0 are coated with the other ingredients. This results in high granulation efficiency at low moisture input.

The 30-10-0 formulations may be somewhat more expensive than preneutralizer formulations, but they are convenient and useful when the demand for high-nitrogen grades is insufficient to justify the expense of installing a preneutralizer. Also, there may be some improvement in physical properties since the least hygroscopic materials form the coating of the granules.

Typical formulations that were tested in the TVA pilot plant are given in the following tabulation. Granulation efficiency was good in these tests; 60 to 75 per cent of the product was onsize (6 to 16 mesh) before crushing the oversize. The products contained 1.5 to 2.5 per cent moisture before drying and about 0.5 per cent after drying. Conditioning with 2.5 per cent kaolin or other good conditioner was considered desirable to provide good bag-storage properties. The formulations shown allow room for the conditioner.

Typical Formulations For Granular Fertilizers Based On 30-10-0

Grade	20-10-10		21-14-7	15-15-15
Formulation, lb./ton of product				
Nitrogen solution	98	—	—	—
Anhydrous ammonia	—	60	60	66
Granular 30-10-0	1194	1233	1280	875
Ordinary superphosphate	401	133	—	—
Concentrated superphosphate	—	128	328	469
Potassium chloride (fine)	338	338	232	512
Sulfuric acid (66° Be.)	—	122	94	75
Water or steam	30	30	30	36

In the first formulation shown for 20-10-10, no sulfuric acid was used, and steam was used to obtain granulation. In the other formulations in which sulfuric acid was used, water was added to control granulation.

When granular materials are used in formulations to make granular products, it is likely that the different size fractions of the product will differ in chemical composition. This problem is familiar to many manufacturers of mixed fertilizers who use coarse or granular potash as an aid to granulation. Mr. Kingsbury gave us a very good discussion of this problem and means of coping with it last year. Briefly, the most effective methods are (1) to size the product closely and (2) to avoid coning of the pile when filling the product bins. A means of filling the bins that minimized segregation was described by Mr. Kingsbury at last year's Round Table meeting.

When coarse or granular materials are used in granulation formulations, it is desirable that the hull of fine ingredients of the formulation should adhere to the granule. Good adherence was obtained with 30-10-0 and 18-46-0 in our tests.

This concludes my presentation. The next speaker is Dr. George E. Smith, University of Missouri, I believe he has much useful information and I hope that he will be able to tell us how materials should be made to put in bulk bins so that they will not segregate. Incidently, Dr. Smith has come here at his own expense. Dr. Smith.

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2. Hignett, T. P., Hicks, G. C., and Jordan, J. E. *Com. Fertilizer and Plant Food Industry* 93, 24-26 (October 1956).
3. Silverberg, Julius, Spencer, N. L., and Douglas, J. R., Jr. Comparison of the Costs of Liquid, Bulk-Blended, and Granulated Mixed Fertilizers. Presented at 140th national meeting of American Chemical Society, Chicago, Illinois, September 1961.

Bulk Blended Fertilizers

George E. Smith

THERE has been a substantial increase in the size of farms, the average age of farmers, and the use of fertilizers in the Midwest. There is much interest in mechanization of all farm operations and the minimizing of hand labor. The handling of bagged fertilizers is now one of the most laborious tasks in crop production. Truck spreading of bulk fertilizers is gaining in popularity. Bulk blended fertilizers accounted for about 28% of the available nutrient tonnage sold in Missouri last year.

People with trucks for spreading limestone and rock phosphate have beenquick to provide the service for spreading fertilizers. There has been a rapid increase in the number of fertilizer blending plants. The number of these plants in Missouri has increased from 20 in 1956 to over 125 at the present time — and more are now being constructed. There are few farms in the better crop-producing areas of Missouri today that are more than 25 miles from dry blending plants. Emphasis has been placed on the lower costs by those selling and spreading blended material, but in many cases the labor-saving feature outweighs differences in costs. Where acreage is large and labor scarce, many farmers will not use band applications at seeding, but want fertilizer custom spread. An increasing amount of fertilizer applied to small grains is now being broadcast. Some farmers are having grass seed mixed with the fertilizer and spread to save one additional operation.

Segregation of Dry Mixed Materials Studied

Studies of segregation in loading, hauling, and spreading of dry blended fertilizer material were initiated by the Missouri Experiment Station following changes in the Missouri Fertilizer Law in 1959. A large amount of data has been accumulated. It is evident now that problems of segregation in mixing and loading of trucks are entirely different than those that occur when the dry blends are spread by fan-type trucks.

What Was Done

1. A number of nitrogen, phosphorus, and potassium-containing materials were mixed in a modified concrete mixer to furnish from 200 to 300 pounds of a 1-1-1 mixture. These mixes were dropped 9 feet through a 3-inch opening into the center of a cone-shaped container. The equipment was designed to exaggerate the segregation that might occur in loading a truck. Samples were collected from the mixer, and from the center and sides of the cone.

2. A stationary 18-foot truck hood with a single fan was constructed. This equipment was used to measure the effect of fan speed and fin adjustment on the distribution of single sized particles on materials having different sieve analyses, and on various fertilizer mixtures.

3. A spreader truck bed (2 fan-chain bottom) was partitioned to provide a 2-foot, and an 8-foot section.

   a. A number of fertilizer mixes containing approximately 240 pounds each of N, P_2O_5 and

K_2O were blended in a batch mixer and poured into the 2-foot section. Each lot was sampled five times: from the spout, at the plant, and after driving 10, 20, and 30 miles.

b. Fertilizer materials to supply approximately 960 pounds each of N, P_2O_5 and K_2O were blended in a batch mixer and poured into the large section of the truck bed. The variation in composition was determined from 10 samples (9 cores each) before the truck left the plant. Triplicate samples were also collected after the truck had traveled 10, 20, and 30 miles. Analyses of these samples were compared with those obtained where the same materials were mixed with an auger, or where bags were opened and the materials stratified in the truck bed.

4. Tests were made on various types of trucks where the same ingredients were mixed.

5. Canvas covered frames were attached to the truck hoods used for field spreading and samples were collected from: between the truck wheels, outside of the wheels, and near the end of the hood. On the larger loads these samples were taken from full loads, when the truck was half empty, and when only a small amount remained in the truck bed.

6. Samples of fertilizer for chemical analyses were collected from pull-type broadcast spreaders where the materials were either blended in a batch mixer or stratified by hand from bags.

7. Crops (grain sorghum, Sudan grass, and wheat) were used to measure variations in spread.

8. A satisfactory method has been found to collect samples from trucks without hoods. Mr. Alva Preston, Jr., of our Extension staff is now working with truck spreaders to determine the evenness of spread of bulk and blended materials.

Segregation of Different Materials

Where dry fertilizer mixes were dropped into a cone shaped container (similar slope to sides of a truck bed) much variation in analysis was found between the sample taken from the center of the cone and from the sides. There was little variation between calculated analysis and of samples taken from the mixer. The least segregation was found when the shape, density, and particle size of the material used were similar. An exception to this general conclusion was observed when one or more materials had a small particle size and were "sticky." One lot of 0-54-0 and one of ammonium sulfate used in early 1959, had a high percentage of fines and did not flow freely. When they were mixed with a number of other materials of different sizes, segregation was minor. However, it was later found that segregation in pouring into a simulated truck bed is entirely different than when the mix is subjected to the force of a spreader fan. Such extremes as the mixing of calcium meta phosphate and coarse potash gave some of the largest variations. This work demonstrated that through proper selection of materials it is possible to make dry mixes that would meet the requirements of the fertilizer law in most states.

Blending plants are now giving much attention to the properties of the materials they use. During he year ending June 30, 1961, 11% of the bagged fertilizers and 17% of the blended material sold in Missouri failed to meet guarantee. Although the bagged good show a higher compliance, some blenders have better records than regular mixing plants.

Simulated Truck Spreading

A stationary 18-foot truck hood was equipped with a standard single fan with the necessary mechanism for dropping the fertilizer on the fan and for changing fan speed. Considerable time was spent in adjustments to secure an equal throw to both sides of the hood. Dropping the material across the hub of the fan parallel to the center of the hood resulted in a greater quantity being thrown to the right. A divider was constructed that placed the material in front of the fins, which gave an equal distribution to both sides of the truck. Results then were equivalent to those later found with well adjusted 2-fan trucks.

Measurements of the effect of fin adjustment and fan speed were studied using closely sized particles (limestone) and a number of fertilizer materials used in making blended mixes. The results, though rather elementary (no published information has been found to date) show that larger particles are thrown farther at higher fan speeds than smaller ones. The most even distribution patterns were obtained where particles ranged in size from 10 to 30 mesh. The data given in accompanying tables show the distribution of single materials with widely different properties and sieve sizes. It appeared desirable to have a range in particle sizes, rather than for most of the material to be in a very narrow range of sieve sizes. It was of particular interest that material 9, a fine 54% superphosphate, gave a uniform mix with various nitrogen and potash materials in the cone segregation tests, but did not give an even pattern from the spreader fans.

Work With Trucks in Field

With the assistance of two blending plants having different types of equipment, mixes were prepared and hauled in regular spreader trucks 30 miles over black-top roads, where spreading tests were conducted and application made to replicated field plots. Samples that could be treated statistically were obtained at the plant, and after 10, 20, and 30 miles of travel. Samples collected after varying distances of travel showed little variation except where calcium meta phosphate was mixed with coarse materials. It was surprising for us to find that where the only mixing was "augering" the combined materials into the truck, or stratification in the truck beds by breaking bags, the sample taken from truck beds (9 probes per load) or the analysis of the mixes that reached the soil, did not show much greater variation than where the materials were thoroughly blended. Apparently the mixing in preparing the materials for analysis or the mixing by the trucks produced a high degree of uniformity. The composition of materials spread from three-hopper trucks was as uniform as where materials had been thoroughly batch mixed. The results showed a wide variation in evenness of spread from the different trucks used — all of which were fairly new and were being regularly used in field applications.

Crop Yield Measurements

Fertilizers from these spreader trucks were applied to replicated field plots. Blends of different materials were applied with the same truck. The spreading by a number of trucks was compared where the same materials were mixed. Ammoniated complete fertilizers were included in the trials. These treatments were compared with both blended and formulated materials that were applied with pull-type spreaders.

Little difference in yield could be noted where Sudan grass or grain sorghum was the test crop. Wheat showed uneveness due to variations in fertilizer distribution. The wheat was harvested with a 6-foot combine — three swaths for each 20-foot plot. Where plots that had received applications of the same materials from different types of trucks, only 3 swaths of 33 comparisons (11 plots) showed significant variation in yield within plots. When the method of mixing was the only variable (spread by one truck) only 7 of 39 comparisons showed significant differences. Where kinds of raw materials were compared, and this included stratification in truck beds, (no mechanical mixing) the yield differences were significant in only 4 of 54 cases. Included in these comparisons were treatments where the fertilizer materials were stratified in a pull-type spreader. Two of these four significant yield differences were obtained with the pull-type equipment. Where average yields of entire plots of the four replications were compared there were some significant yield variations. However, there were no consistent variations due to kinds of materials or spreading equipment. In one experiment the low yield was obtained from formulated material spread by truck, and a high yield was produced where the raw materials had been stratified in a pull-type spreader.

Adjustment of Trucks Important

Experience gained with a limited number of trucks indicated a wide difference in spread patterns. Measurements showed that observing particles on the soil did not indicate an even spread. Where trucks were equipped with hoods it was possible to obtain good data on the spreading pattern. However, many methods were tried before satisfactory measurement could be obtained on spreader trucks without hoods. Canvasses, trays or pans for collecting samples were not accurate. The particles either skipped or bounced and the amount collected did not represent that coming to rest on a specific area of soil. A method has been developed (essentially a frame with a venetian blind enclosed) and reliable data on distribution patterns are now being obtained from trucks without hoods, and where fans are revolving at proper speeds.

Since these methods of collecting samples have been in use, tests have been made on 17 separate trucks at a number of bulk fertilizer installations . Samples were collected at 7.5-foot intervals from the center of the truck and the total weight, N, P_2O_5 and K_2O analysis obtained. Had it been possible to obtain samples at 1-foot intervals the curves would probably be smoother.

It is evident that an "average" truck does not exist. The proper adjustment of the truck is obviously one of the biggest problems in the distribution of bulk materials. Of interest, too, is the difference in performance of the same make and model of spreader. This suggests that all variables (speed of truck, speed of fan, placement on fan and fin adjustment) must be considered in adjusting and correcting difficulties.

The following data obtained on four trucks are typical of the spread patterns that have been measured and show the numerous variations possible with varied equipment, materials and adjustments.

Truck I

This was a 2-fan truck with no hood. A 14-14-14 was prepared by using:

	+10	+20	−20
Ammonium nitrate	43%	57%	0%
T. S. P.	43	56	1
KCl	79	21	0

The fan speed was obviously too slow since little material was found beyond 15 feet from the center. The sample collected from the center of the truck measured 741 pounds per acre, with only 91 pounds at 15 feet on the right side and 237 pounds on the left, at this distance. The operator had been driving at 30-foot intervals. This gave a distribution that varied from 182 to 741 pounds of material per acre when measured 7.5 feet from center. It is probable that a higher fan speed would have given more even distribution. A 30-foot driving interval is too wide for this truck. Adjustments need to be made to provide a more equal distribution of material to the two sides.

Truck B

This 2-fan truck was new and equipped with the most advanced attachments. It was equipped with a hood. A 19-19-14 was mixed by using:

	+10	+20	−20
Ammonium nitrate	1%	99%	0%
18-46-0	29	70	1
KCl	42	39	19

This truck spread more to the right than to the left. With the materials used a greater amount was spread at 7.5 feet from the center than immediately behind the truck. This suggests that the fan speed was too great for the materials being used. Driving at 30-foot intervals, the rate of spread varied from 372 to 560 pounds per acre. A closer driving pattern would increase the evenness of distribution.

Truck O

This truck was equipped with a single fan and no hood. A 20-10-10 was used in the spreading tests, and made from:

	+10	+20	−20
Ammonium nitrate	61%	38%	1%
18-46-0	40	59	1
KCl	11	87	2

The pattern of spread was typical of that observed with a number of 1-fan trucks. More was spread to the right than to the left. Only 79 pounds per acre of material analyzing 19-12-10 was found 15 feet to the left of center, while 234 pounds per acre of a 19-13-10 was collected in the area 15 feet to the right. If the trucks returned across the field at a 30-foot interval this would produce a variation in distribution from 176 to 468 pounds per acre. If this truck drove around the field the distribution would be improved. Some adjustment of fall on the fan could probably improve the pattern.

Truck L

This single fan truck with a hood, gave one of the best patterns of distribution of any that were tested. In this run a 12-12-12 was made from:

	+8	+20	−20
Ammonium nitrate	58	40	2
18-46-0	49	51	0
KCl	15	71	14

Very little material was thrown beyond 15 geet, so that a 30-foot driving interval was too wide. Some adjustments in the fall of material on the fan could also improve the distribution pattern. Some improvement could have effected by driving with the "lap" to the previous center line, but not as much as with other trucks tested.

Trucks Must Receive Attention

Trucks for spreading blended or bulk fertilizers must receive attention to obtain the most even spread. Trucks designed for spreading lime are generally not satisfactory. Badly worn equipment should not be used. Truck operators must understand their equipment, make proper adjustments and practice careful driving. Materials used in blending must be of proper sieve size to minimize segregation from the fans. Interest of truck operators has been excellent. Some drivers understand the operation of their trucks much better than others. There is much interest in giving customer satisfaction.

When phosphate potash and lime were the principal materials spread the customer could not observe striking crop differences due to uneven distribution. However, with an increase in the proportion of nitrogen in mixtures and smaller rates of application, the uneven distribution of nitrogen is often evident on small grains and grasses. With the increased use of bulk spread material, improvements in distributions are essential.

Farmers recognize this difference in trucks and the skill of drivers. Reports have been received that some farmers will insist that a particular driver do their spreading.

Conclusions

1. *Materials*

   The materials used in bulk blending should have similar size, shape and density. By giving attention to the use of proper materials, blends can be prepared that will meet the requirements of fertilizer laws.
2. *Loading Trucks*

   Segregation of blended materials in trucks can be minimized by not permitting materials to "cone" and by keeping the "roll" to a minimum.
3. *Sieve Sizes*

   The best distribution has been obtained when materials are in the sieve size range of −8 to +20. The data obtained suggest a range in particle size is more desirable than when most of the materials have a narrow range in diameter.
4. *Hauling Distance*

   Little segregation occurred when materials of acceptable sizes were blended and trucked for 30 miles.
5. *Number of Fans*

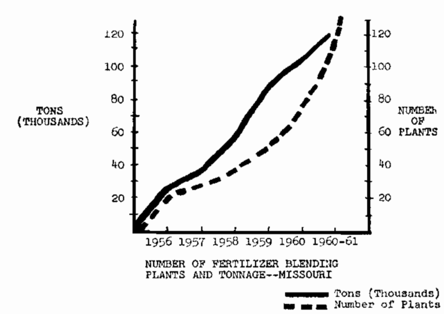
   When the materials are dropped in the proper position on the fans as even a distribution has been obtained with one as with two fans. In many cases there is a greater tendency for 1-fan trucks to throw more material to one side.
6. *Fan Speed*

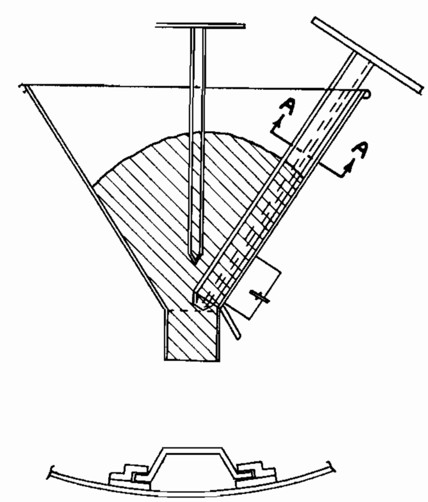
   In work with a number of trucks the best spreading patterns have been obtained with fan speeds of 550 to 650 R.P.M.
7. *Driving Pattern*

   The distribution patterns of many of the trucks checked could be improved by reducing the "lap" so the distance of throw would reach the center line of the last pass of the truck.
8. *Crop Yields*

   Crops showed visible differences in growth due to unevenness in spread of blended materials. However, average yields have been as high as where formulated materials have been spread by the same trucks or by broadcast pull-type spreaders.

It would appear that the fertilizer mixing industry has completed a cycle. Originally dry materials were mixed by hand or with simple equipment and sold to farmers. Ammoniation and the use of nitrogen solutions resulted in more elaborate mixing—and granulating equipment. With the services now demanded by Midwest farmers, and the savings in costs that can be effected in bulk handling, it appears that dry mixing by blenders will grow. There are problems to be overcome, but the proper selection of materials and the use of adequate spreading equipment will make blended materials a significant portion of our fertilizer tonnage.

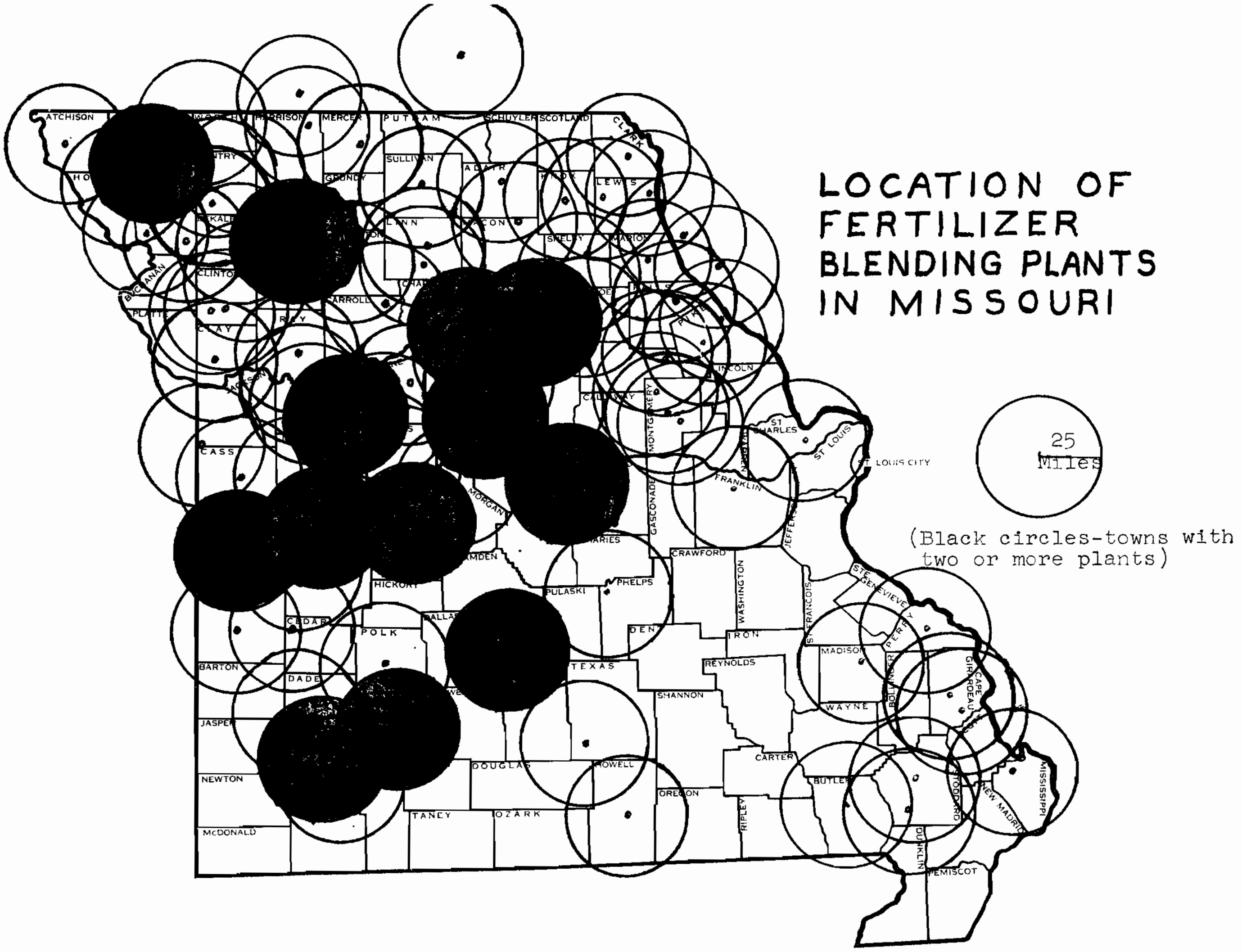


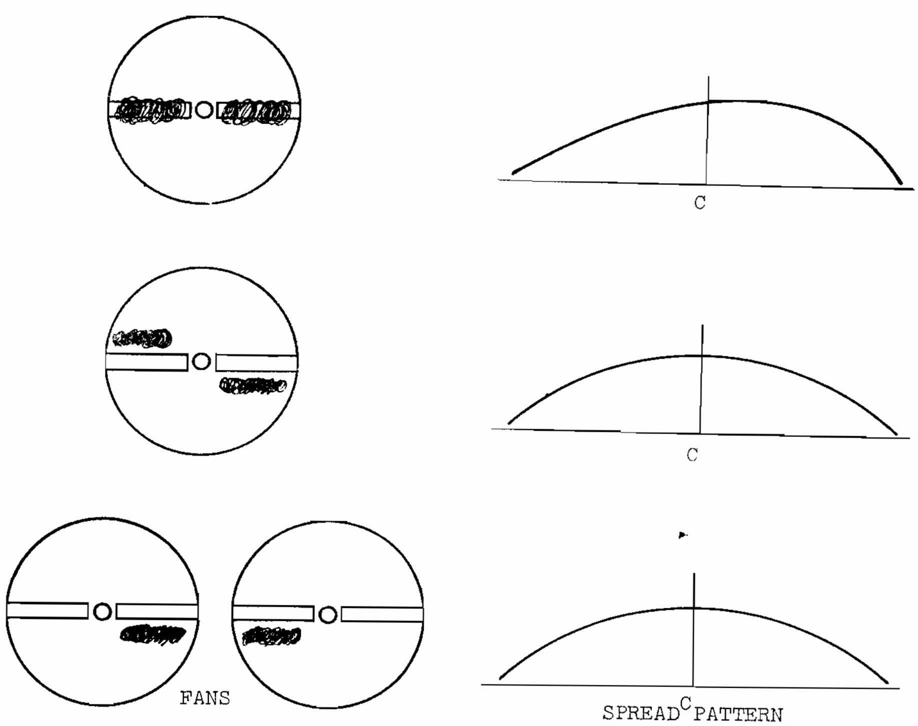


SECTION A-A

CONTAINER FOR MEASURING FERTILIZER SEGREGATION

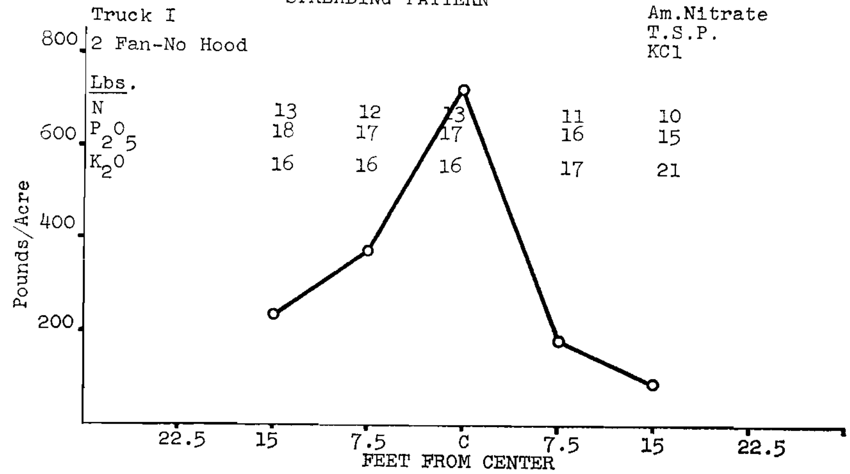
LOCATION OF FERTILIZER BLENDING PLANTS IN MISSOURI



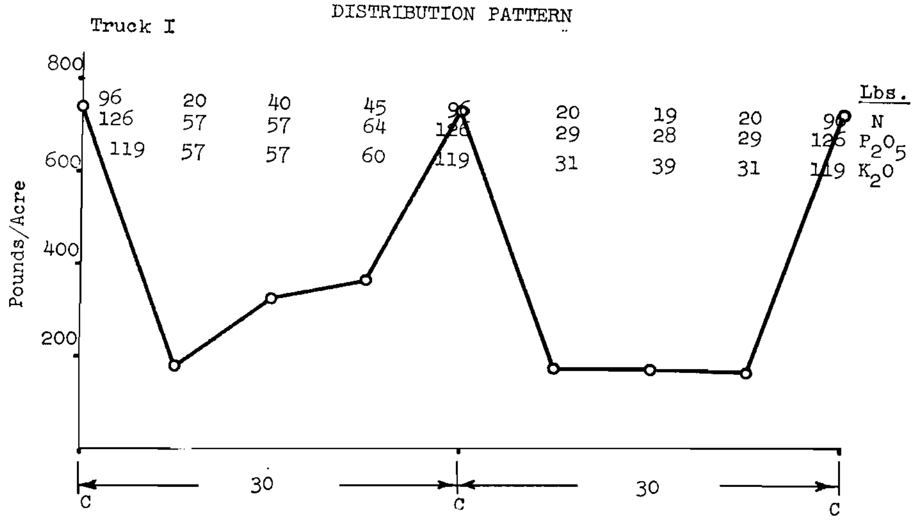


DISTRIBUTION OF FERTILIZER FROM DIFFERENT SPREADER TRUCKS

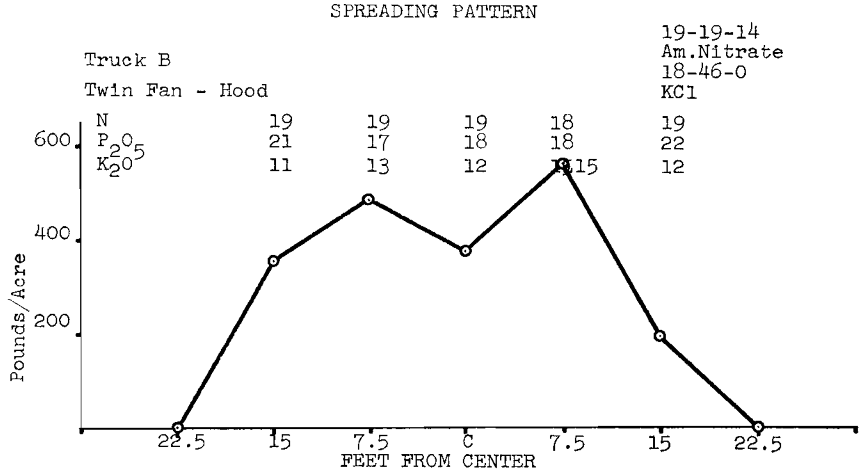
SPREADING PATTERN



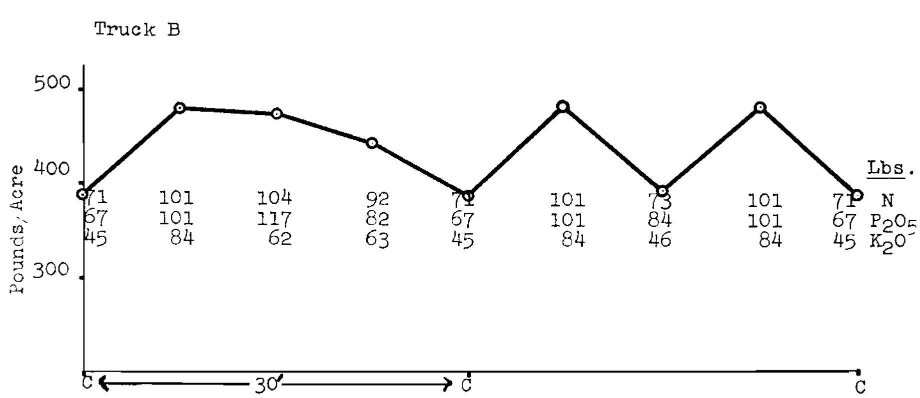
DISTRIBUTION PATTERN

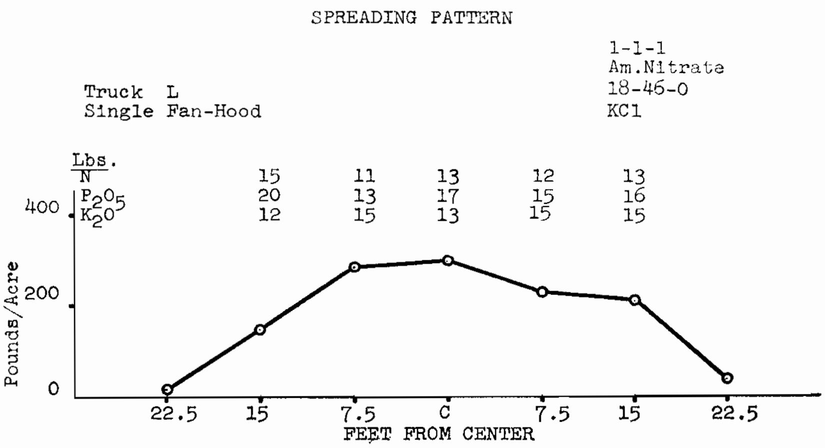


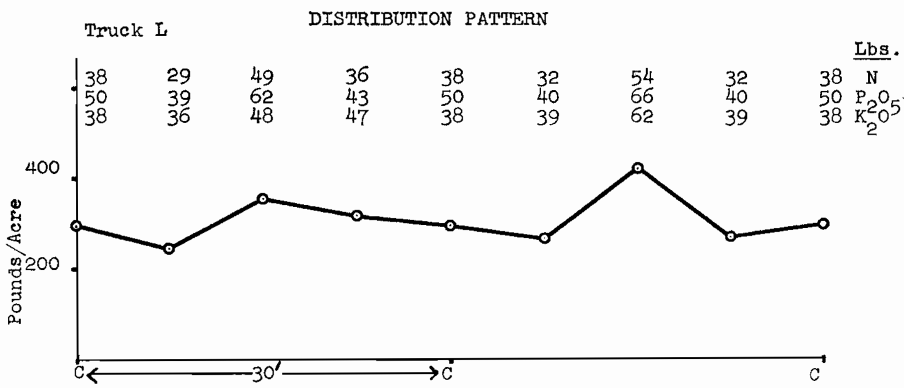
SPREADING PATTERN

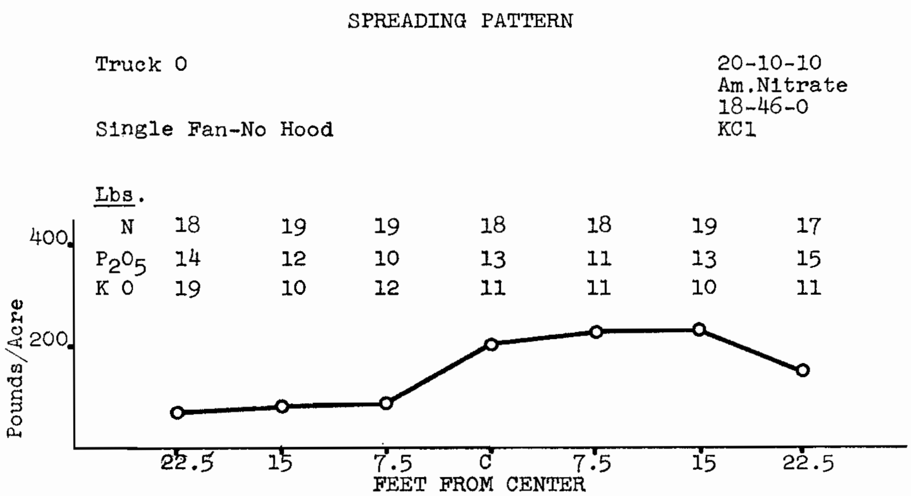


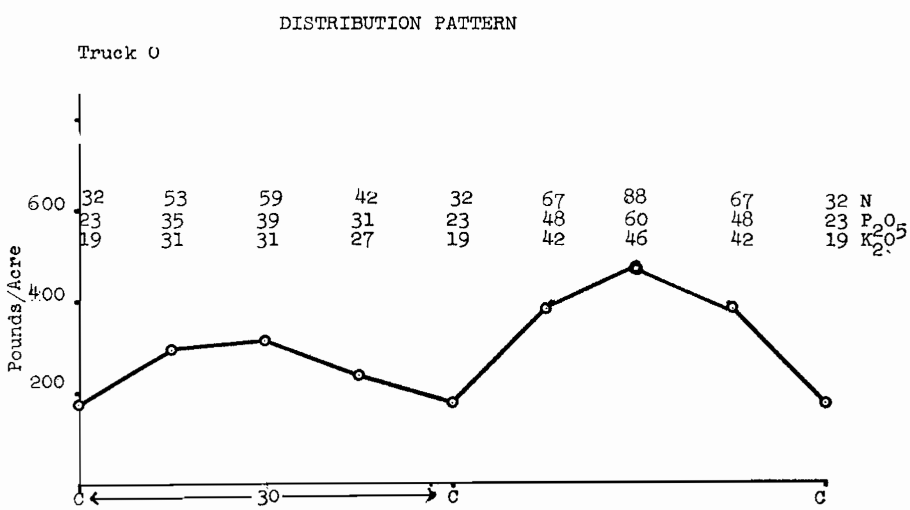
DISTRIBUTION PATTERN











Distribution of fertilizer materials by simulated spreader truck. Single fan-670 R. P. M.

No.	Material	% of particles in 3-ft. sections from center of truck 0-3	3-6	6-9	9-12
17	45% Super.	28	29	28	15
7	Cal-Meta-Phos.	25	42	29	4
9	54% Super	31	46	21	2
6	KCl	19	31	34	15
19	KCl	24	39	33	3
8	21-53-0	22	42	31	5
23	18-46-0	24	30	35	11

Distribution of nitrogen materials by simulated spreader truck. Single fan-670 R. P. M.

No.	Material	% of particles in 3-ft. sections from center of truck 0-3	3-6	6-9	9-12
10	Am. Nitrate	25	36	26	13
12	" "	32	34	28	5
11	Urea	30	32	32	7
22	"	26	32	33	9
13	Am. Sulfate	26	60	14	Tr.
15	" "	24	32	32	12

Effect of Fan Speed on Spread of Sized Limestone Particles. % of Sample Collected

Distance from center of truck (Feet)	Sieve Sizes -8+10, Fan Speed—R.P.M. 300 %	490 %	670 %	-10+32, 300 %	490 %	670 %
0-3	26	24	26	27	26	22
3-6	42	30	31	50	24	34
6-9	30	33	32	22	41	36
9-12	20	13	11	Tr.	8	7

Effect of Truck Spreading on Variation in Yield of Wheat

Variable	Comparisons	Significant Differences
Kind of Truck	33	3
Method of Mixing	399	7
Kinds of raw Materials*	54	4

*Also included spreading of stratified materials with pull type broadcast spreader—2 significant differences in broadcast spreader plots.

There were no significant differences in yield when all areas from 4 replications of truck-spread materials were averaged.

Fertilizer Analyses from Cone Segregator (1-1-1 Ratio)

Materials Used			Center of Cone			Side of Cone		
N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	25	6	14.8	14.2	15.8	14.8	19.5	9.9
1	25	20	14.7	15.1	14.6	11.4	14.7	20.8
2	9	3	11.9	13.7	11.3	11.0	14.4	12.1
10	25	6	15.2	15.7	12.7	20.0	14.7	6.9
20	7	18	15.9	17.4	16.0	19.0	8.9	18.9
21	25	19	14.3	14.3	17.0	17.8	17.9	6.4
21	25	20	15.0	15.0	15.4	14.2	13.9	18.9

MODERATOR SPILLMAN: Our next speaker is Mr. Philip E. Stone.

Experiences With Diammonium Phosphates

MR. PHILIP E. STONE (Virginia-Carolina Chemical Corporation): My remarks will last only about 10 minutes. I think since that is the case, in spite of the fact that these seats are real comfortable, would it be all right if everybody stood up for 30 seconds?

MODERATOR SPILLMAN: Yes, indeed.

MR. STONE: Let's be seated, gentlemen.

Just before standing up, I had a drink of this good ice water up here on the table and I am reminded that somebody's mother once said that, "I know my son doesn't drink whiskey, because he likes ice water so well." I know it tastes mighty good to a lot of people in the audience today. (Laughter.)

This fellow, Travis Hignett, is a fast-talking gentleman. I am glad he's from Alabama instead of North Carolina, because if he were in North Carolina they'd make him a tobacco auctioneer. I'm just kidding, Travis. When I say he's a fast talker, I mean he's smooth and persuasive. He called me at least a couple of months ago and asked me if I would participate on the program. He told me that he had called all of the qualified people that he knew.

(Laughter.)

—and he asked me if I'd be kind enough to say a few words and I agreed. Where friendship is concerned, I have absolutely no pride, so I'm here and I'll talk to you about 10 minutes, mostly about diammonium phosphate and some of the experiences that we have had in V.C.

I would like for you not to construe my presence here as being an expert in this field because I certainly am not; we have much to learn.

In recent months the grades and the tonnage of solid high analysis materials have increased considerably. Some of these high analysis materials are already produced on full commercial scale and other similar materials are still in pilot plant and semi-commercial production.

A few examples of these high analysis materials are 13-0-46 or something similar. This is a nitrate of potash. Others are 30-10-0, 0-54-0, 15-59-0, 12-52-0, 18-46-0, 16-48-0, 21-53-0, and I could continue. There are others that I haven't listed. Diammonium phosphate is included here, but, of course, it is still relatively a new material and its use is certainly growing rapidly in the field of granulation and in blends.

These high analysis materials permit more flexibility in formulation of both granulation and blend grades than has been the case in the past. It is now possible to formulate the same grade in many different ways. The formula adopted for a given grade at a given plant is largely governed by the cost of the materials which make up the formula, by the production equipment available and by the quality of fertilizer which results.

Although these high analysis materials have given the production man a greater choice in the selection of formulas, they have at the same time made the job of formulation more complex than ever before. This is particularly true at those plants which use ammoniation methods to produce complete goods in either granular or semi-granular form. At these plants it is now more necessary than ever before to evaluate and to re-evaluate the formulas in use to insure the production of low cost, high quality fertilizers.

I would like to make a few comments on just one of these high analysis materials, diammonium phosphate. This material is in greater use today than the other materials mentioned and the industry therefore knows more about its behavior in factory equipment. It should be pointed out, however, that much still remains to be learned about the behavior of D.A.P. when it is mixed with many other new materials in many different formula possibilities.

D.A.P. has made it possible to produce high analysis grades that could not be manufactured with the old standard materials used by ammoniators, such as nitrogen solution, sulphate of ammonia, 20 per cent super, triple super and sulfuric acid.

At some locations we have found that pulverized D.A.P. can be used to advantage in formulas where it is not added specifically to make high analysis grades. In such cases it is added to lower the formula cost and to improve the physical properties of the products. Of course, blenders find D.A.P. very useful as a source of soluble nitrogen and phosphate in all kinds of grades.

Generally speaking, D.A.P. is a very useful material to ammoniators and to blenders as well. Like all materials D.A.P. must be properly used in formulation. When it is not properly used, it can sometimes present as many problems as it solves. I will comment on one or two problems which sometimes face ammoniators. Sometimes, in relatively low analysis grades, small amounts of D.A.P., say, 25, 50 pounds, are added to make grade. Because of the coarse D.A.P. particles and the high analysis of the material, poor mixing and also segregation cause erratic chemical analysis. In ammoniation formulas, we try to use at least 100 pounds of D.A.P. in an attempt to reduce this problem. This 100 pounds is a purely arbitrary figure. In some low nitrogen grades, produced by ammoniation methods, too much D.A.P. may be used, which in turn reduces the nitrogen solution requirement to a point where there is insufficient ammonia to develop the heat and liquid phase needed for granulation. When this happens the product quality usually is unacceptable because of the high fines content and the dustiness of the product.

In plants equipped with steam their lack of chemical heat is usually no problem because the heat released by condensing steam in the ammoniator is a good cheap substitute for chemical heat.

In grades having relatively high nitrogen contents, say, 12 per cent or above, the use of D.A.P. in ammoniation formulas does not necessarily reduce the amount of nitrogen solution and therefore the problem of insufficient heat for granulation does not arise. In these cases, the nitrogen from the D.A.P. usually replaces the nitrogen from sulfate of ammonia, rather than from solution.

D.A.P. may be used in some formulations to reduce the sulfate of ammonia requirement and to reduce the triple-super requirement. The reduction in triple-super often makes it possible to use more 20 per cent super. These changes can result in lower formula costs. Examples of grades where these changes might permit savings are 10-20-10 and 12-12-12. We would like to emphasize, however, that each plant must be considered as a separate problem. Material costs vary all over the country and significant savings at one plant may be nil at another.

There is a lot of discussion these days about the physical and chemical specifications of various raw materials used in granulation. We would like to tell you about an incident that happened within our own company which has to do with the physical quality of diammonium phosphate. I am not sure what this story proves, if anything. Maybe it just points out the difficulty of producing a material that has particle size properties suitable for all potential users.

When the V.C. diammonium phosphate unit started production, a few months ago, there were the usual start-up problems that all plants experience in getting under way. I recall the mill for crushing the oversized particles was much too active and a supply of fines was accumulated. The amount of fines was larger than needed at the D.A.P. unit for recycle purposes and we decided to ship some of this material to one of our granulating plants. The purpose of the shipment was twofold: it permitted us to get rid of a product that was not needed at the D.A.P. unit and it permitted us to test the use of this material in granulation of complete fertilizers.

This D.A.P. product, containing excessive fines, was shipped to a plant equipped with steam. The superintendent of the plant used the fine D.A.P. product with good success. Formulas containing this material handled well on the granulation equipment and the product quality was very good.

Now that the D.A.P. plant operation has settled down, to steady operating conditions, we don't have any more fine D.A.P. for shipment; nevertheless, we have one superintendent who continues to ask for some of that pulverized D.A.P. that granulated so well.

(Laughter.)

I don't think we'll ever get around to the point where we grind up D.A.P. for this superintendent's particular use but this is just one example of how you can get into problems involving particle size.

We would not like for you to take this story to mean that we are not in favor of improvement of the specification of raw materials used in granulation. We are not only in favor of improvement, however, we think that it is a must. As Shakespeare, or somebody has said, "You can't take a silk purse and make a sow's ear out of it."

(Laughter.)

This concludes my remarks. I appreciate your attention and if there are any questions that I can answer, in my very limited experience in the use of D.A.P. and formulation, I would be very glad to do so.

(Applause.)

MODERATOR SPILLMAN: Thank you, Travis Hignett, Dr. George Smith and Phil Stone for thoroughly discussing this important subject. These men have spent a lot of time in developing this information for you and I am sure you folks out there have some questions.

Those of you who have questions, please give us your name and whom you represent.

Membership standing ovation appreciation to Executive Committee. By E. M. Jones, Nitrogen Division, Allied Chemical & Dye, Indianapolis, Ind. Al, I have been asked by our Committee to interrupt the program right here. I know we'll have some good questions in a few minutes.

Al, you, Vince Sauchelli, Housden Marshall, Joe Reynolds, the Round Table Executive Committee, have spent a lot of hours this past year, as you have so many years before, and I might add a lot of those hours were from your own free hours, in developing a program that would be of general interest to a lot of people, and I think you can see where you have been successful. In addition, you have called on the most able men in the industry to handle the topics that were a part of this program. Again, you have been successful. Witness the attendance here in the last moments of the 1961 Round Table. For this, on behalf of all of the Round Table members present, I wish to express our deep appreciation and heartfelt thanks for a job well done. (Applause; attendance standing.)

MODERATOR SPILLMAN: Your Executive Committee appreciates those very kind words. It has been our pleasure to work diligently to give you a program of most interest in technical information from the standpoint of fertilizer manufacture. We have spent a lot of time; however, when we see this wonderful gathering of people here, we are gratified and we thank you for coming. There were a number of people who helped with this program, especially the speakers. We thank everybody for cooperating with us and are proud for your kind words of appreciation.

Questions and answers. Use of New Materials.

ALBERT SPILLMAN: Mr. Smith, with regard to the process you were describing in your talk, what would you consider to be the minimum amount of granulated fertilizer these machines would adequately spread per acre?

MR. SMITH: They're spreading a lot less than we think they should.

(Laughter.)

That's the best answer, I'm afraid, I can give. It is our recommendation in the college that any time that you use, let's say, less than 200 or 250 pounds of material per acre, we think that it can be most efficiently used in banding. But one of our major suppliers or blenders in the state told me that their average is probably running less than 200 pounds per acre.

I think that it's possible to adjust the truck so that it will do a fairly even job with those quantities, but I would certainly advise, if that is all the farmer is going to use, that he band it. Then if they are not going to band it, we are going to have to do the best job we can with the truck. For complete material I would like to see them held to not less than 300 pounds per acre.

Member: MR. JONES: Your studies showed distribution laterally. Have you studied the distribution to determine how much segregation took place from the beginning to the end within the truck?

MR. SMITH: Yes, in this field work in the colored pictures I showed you, we mixed about seven or eight four-ton loads of about the size I showed in the picture. These four ton loads were hauled 30 miles. We ran a spreading test with the truck full, we applied to a plot in the field. We ran out half of the fertilizer, we put on another spreading test and another plot with about a half a load and then another one with only maybe three or four hundred pounds of material left in the truck. Frankly, the differences were so small that you can't pick them out. It hasn't made very much difference, with the possible exception and, again I'm not picking on TVA, but we did have a little trouble when we started mixing cal-meta with coarse potash, but if you stay within a reasonable size, say, with the three materials being of similar size and shape, you couldn't tell very much difference in it.

We obtained comments from truckers who said, "Well, if you had a chain bottom, you would get a lot closer, it's not necessary to mix it nearly as well, a chain bottom will take care of mixing." We couldn't tell any difference between chain bottom and bell over tanks. I am sure there were variations but they were within a limit of experimental error.

MODERATOR SPILLMAN: We have had a number of questions relating to what effect segregation has in our relationship with the various state control officials. Are there any questions on that particular subject?

ARTHUR SMITH: I'd like to ask a question, Dr. Smith. With the state laws now what they are and reading as they do, and you can't blame this control official, or his inspector, or his chemist, for making the honest effort to enforce the laws as they read, whatever the state law is, but what I would like to ask Dr. Smith, if he cares to answer it, and I assume there are no Missouri officials in this room. (Laughter.) But possibly the fertilizer control officials have not, in some instances at least, put more emphasis or importance on this matter of segregation than experienced agronomists would or do, or than is justified from the agronomical facts or importance of the extent of segregation that on the average has taken place.

DR. SMITH: I am inclined to agree with you. Actually, I think one of the reasons, if you look at our data and you take, for example, the analysis of material that, let's say, is well mixed in the truck but is segregated when the force of the pan was applied to it and maybe, we'll say, it was mixed as 14-14-14 and you wind up out here with an 18-13-12 or something at a certain spot. If the nitrogen varied a lot, you could see the striping in the field.

But when you started averaging up these yields, it didn't make very much difference. This might be true, that if you were using very small amounts, which a lot of our people do, this might be enough that you could measure it. But if you use a good, liberal treatment, it is going to take a tremendous experiment to show any significant difference.

I don't believe that the agronomic aspects are nearly as critical as the tolerances that you have to meet in manufacturing.

I might add this comment. This wasn't asked in the question, but I presume it's all right to go ahead.

We have been accused in Missouri of being more critical and examining, let's say, the blenders more than our neighboring states. Some of the states are merely taking the attitude that the farmer must deal with the fellow that he has respect for his integrity, and if the man says that he puts so many pounds in there, that's what is in it, and let him beware and they don't sample the truck. We require that the truck itself be sampled. I might mention, we have an Attorney General's ruling that they will not let us, with our present law, take a sample as it pours out of the spout, it has to be taken with a probe after it's in the truck. We are requiring the same tolerances of blenders now that we are of formulated bag material. I think I have this in the written part of my speech; however, I forgot to mention it. During the first nine months of last year, I believe, we had 13 per cent of the samples of formulated material that failed to meet guarantee; I believe there was 19 per cent of the blended material that failed to meet the state tolerances; that is, the blenders don't have as good a record, but I can add this: that we have some blenders who are doing a better job meeting guarantee than some of the formulators.

ARTHUR SMITH: May I make another comment and ask another question? In general, if this blending is more economic perhaps it will continue to grow, at least in some areas. The tolerances in most states are reasonable or have been reasonable as to the methods of manufacturing, although there are some states in which the officials have openly stated that if they enforced the law as it reads to the letter, they could bankrupt any fertilizer company doing business in the state. We assume that 99 and 100ths per cent of all the mixed fertilizers are mixed honestly; that is, they have no intention of deficiency. Some few states have very little leeway they will allow in deficiency, or to which they will apply overages against deficiencies. Now if there is segregation and something shows up lower in the sample by analysis, something else has got to show up higher than the guarantee. I am wondering if, since the purpose of fertilizer laws is to protect the farmer as well as the honest manufacturer, and many states have this method of reporting the commercial valuation which isn't the price at all but it is figured up at so much a unit as to whether the fertilizer meets the total approximate value or not, whether the industry and perhaps the agronomists or the agronomy departments of our various states, in cooperation with the industry, might not consider the possibility of prevailing on the state control officials or the people who would be interested perhaps in modifying their laws, if necessary, to arrive at what would be a fair tolerance, applying overages against underrun to bring the control work within practical agronomic importance of this matter of segregation?

DR. SMITH: I think a high percentage of the states have that now. I think ours, if I remember right, any overage can be applied as long as one element isn't off over 10 per cent. If it's off over 10 per cent, why, then there is no overage that will correct the deficiency. I think that suggestion is in the model law and quite a number of states have it, I think.

ARTHUR SMITH: We wouldn't expect it to cover manipulation mistakes, mistakes in the factory, where they have gone up too much in certain areas.

DR. SMITH: In other words, if you have a penalty on 5 per cent and you're off 7 in nitrogen and you're plus 7 in potash, why then there's no penalty. But if you're off 11 per cent in nitrogen, you could have any amount of the phosphate and potash and it couldn't help.

A MEMBER: Dr. Smith, in line with the statement you made a couple of minutes ago in which you indicated that where you would be adding materials in very small amounts in ratio to the materials that would be present there in large amounts, has anybody in Missouri been attempting to add more borax or magnesium or other materials to the bulk blended products, and, if so, what has been the agronomic result?

DR. SMITH: I don't have any information on it. About the only trace element that we are adding is borax in the case of alfalfa fertilizer, and we have not done any work on it. We have no provision in the laws for testing boraxes yet. I know they are doing it but I can't tell you how good a job. Actually, the borax isn't too critical except for alfalfa and then on some soils.

SAME MEMBER: Yes, it would vary possibly with a few pounds in increase which could give you difficulty.

DR. SMITH: In other words, there could be a wide difference in concentration as to the truck. I could use this illustration, this has pretty well been stopped. At one time we had people mixing raw phosphate and coarse potash and they don't sample the truck. I think, that our work has done; it has pretty well stopped that type of thing.

MR. JOSEPH F. PISCO (Standard Oil Company): Dr. Smith, in your work, do you use a constant diameter of pitch also in the field? Do you expect any appreciable differences in the efficiency in the evenness of the spread by varying the diameter of the fan or the pitch of the blades of the fan?

DR. SMITH: We don't change the diameter of the fan, we change the pitch on the blades; that is, one that was used had slots of about three quarters of an inch long and we ran it in advanced, retarded and intermediate positions. It had a little bit of effect on the throw but not nearly as much as we were led to believe.

As far as the diameter of the fan is concerned, we have not checked that except as it might apply on some of these different trucks.

We have worked with quite a number of makes of trucks and, as I say, we haven't found one truck yet that's doing what we consider a 95 per cent job.

MR. PISCO: Do the standard size fans then fit?

DR. SMITH: What we've done in this work we did with the simulated truck. We bought a standard fan from a parts company. We constructed this and then the other work has been with the trucks as we have found them out in the field. In other words, we started in innocent. Here was a truck that had spread, maybe, 40 or 50 tons of material. It still had good red paint on it and the fellow says it works good. We spread a lot of fertilizer before we found the fan was running too slow and we have just taken this about as we have found it. We haven't gone into these details.

MR. HIGNETT: I'd like to ask Dr. Smith a question as to how critical the particle shape is? In much of the potash particularly, granular potash, if they are the same size, how critical is the shape?

DR. SMITH: I don't have any good scientific evidence on this. In some laboratory work we have done, I think we have gotten some pretty good evidence that it would be desirable to have them all the same shape. In other words, if you could have them all angular or all round, and not have them mixed. In fact, I think I approached your people at one time about making angular superphosphates to go with angular potash and angular ammonium nitrate, but — maybe this shouldn't go in the record — in connection with a demonstration I had to put on for the legislature at one time to demonstrate segregation and non-segregation. The material that I used for the non-segregation — pardon me for mentioning names here, I took, I believe it was Southwest potash, this nice red material, and got it down to one single size with a screen. I was only dealing with a gallon or so. I took commercial soil and some ammonium nitrate and got it to exactly the same and then I took some U. S. Steel ammonium sulfate and painted it with blue lacquer so I had some red, white and blue material and it made quite an impression on the legislature.

MODERATOR SPILLMAN: Was there a question back there?

A MEMBERS Mr. Smith, did you by any chance ever come up with a truck spreading equipment of other than the spinner type such as you have described?

MR. SMITH: No, we haven't as yet.

MODERATOR SPILLMAN: I wish to take this opportunity to welcome our good friend Dr. Forrest W. Quackenbush, Indiana State Chemist, Purdue University. I was wondering, Doctor if you had any comments you would care to make at this time?

DR. QUACKENBUSH: I don't think so. I came here to listen, and I've learned quite a lot.

I am exceedingly interested in the discussion which Dr. Smith has presented, because we have, as many of you people here know, a good deal of bulk blending getting under way at a little higher speed now than formerly was in the State of Indiana. We have many of the problems Dr. Smith has been talking about, and, this has been exceedingly interesting to me. I don't know if you have any specific thing that you would like for me to comment on. I would be glad to try to do this, but I have nothing at this time.

MODERATOR SPILLMAN: We're glad to have you, Dr. Quackenbush, and we appreciate your attendance.

Are there any other questions? We have time for a few more questions?

(No response.)

If there are no other questions, I have one comment to make.

Your committee appreciates the compliments given us, however, most of the success of our Round Table Meetings must be credited to our speakers for the outstanding presentations of their respective papers.

I thank you all again for your wonderful cooperation and if there are no further questions I'll turn the meeting back to Joe Reynolds.

MODERATOR REYNOLDS: Gentlemen, we have just about come to the conclusion of our 1961 Round Table. We believe that the meeting has been a success, thanks to your loyal participation and helpfulness in putting this program together and putting it on. It is always our privilege and pleasure to moderate these sessions and to participate with you and to get to know you better.

The Round Table remains as your Round Table. We can only grow as your interest remains and grows with us. This is a most unique group, it has been referred to as that in many aspects, but it's true; it's a very large, informal group where the individual is recognized and is very important.

I know you are interested, as far as our registration, and we are pleased to report that the total figure for the 1961 Round Table Program was 434, which is a new high.

The wheels of planning for the 1962 Round Table are already in motion. We, your Executive Committee, solicit your suggestions and ideas. This flow of information to us is vital to assure that the program reflects your thoughts and ideas. Let us hear from you.

We will probably send out some questionnaires a little later on as a reminder to you in some way to encourage some correspondence coming back to us.

We, your Executive Committee, wish to express our sincere appreciation for your kind attention and interest throughout this session and the sessions which have gone before. It is also a personal pleasure to work with you and the other members of your Executive Committee.

It is not my purpose to keep you any longer. However, if there are any last minute questions or comments, this is your last chance before this illustrious group is adjourned.

(No response.)

I am assuming that everybody is just about ready to go home.

If there are no further questions or comments, the 1961 Round Table is adjourned.

Thank you very much.

(Applause.)

(The Round Table adjourned at twelve twenty o'clock p.m.)

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